TAMPEREEN TEKNILLINEN YLIOPISTO
TAMPERE UNIVERSITY OF TECHNOLOGY

KRISTIAN BATISTA

CREATING A BUSINESS GENERATION MODEL TEMPLATE IN A MEDIUM SIZED FINNISH COMPANY UTILIZING CASE OF WASTE TREATMENT IN SULTANATE OF OMAN

Master of Science thesis

Examiner: professor Petri Suomala and DSc Tuomas Korhonen
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ABSTRACT

KRISTIAN BATISTA: Creating a business generation model template in a medium sized Finnish company utilizing case of waste treatment in Sultanate of Oman
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In this thesis a general template for business model generation for a medium sized Finnish company was created. The template was created and tested by utilizing the case of waste utilization in Sultanate of Oman, which was a relevant research and business model topic for the company.

The purpose of this thesis is to support market entry in emerging markets in case of waste utilization in Oman. One research question and one operative goal were formed to fulfill the purpose of this thesis. The research question is: how to take into account the customers' decision making process in business model generation. This research question was selected to the thesis to analyze the customer's decision making and to provide a method and tools to be used for this purpose later in the same company. The providing of the tools and methods is important, as the thesis was intended to function as a template for future business generation scenarios in the company. The operative goal was formed into a question: what are the proposed technology concepts and investment opportunities for treating waste in Oman. The answer to this question was designed to answer the case specific questions and to give concrete solution suggestions.

The waste streams in Oman were analyzed and five collection clusters were created. This collection solution covers over 98% of the Oman's registered non-hazardous waste. Seven different technology concepts were analyzed for the three biggest collection clusters and two technology concepts for the two smallest collection clusters. The analysis was performed by utilizing profitability calculations and multi-criteria decision-making tools. The profitability calculation results functioned as one type of input for the multi-criteria decision-making tools. The other type of input was more abstract and intangible information about the customer value and each technology concept's performance per defined criteria in the multi-criteria decision-making tools. This more abstract information was collected in three iterative stages to ensure the reliability of the collected information.

The results of the multi-criteria decision-making simulation favor the technology alternative 2 in disposing of the waste. The business model was created by utilizing the information that the simulation provided and thus the business model relies heavily on the technology alternative 2. Finally the business model was illustrated by utilizing the Business Model Canvas and the template nature of the thesis for the further use was discussed.

TIIVISTELMÄ

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Tässä diplomityössä kehitettiin keskisuurelle Suomalaiselle yritykselle business kehityksen malli. Tämä malli kehitettiin ja testattiin tutkimalla Omanin sulttaanikunnan jätteenkäsittelyä, sillä Omanin jätteenkäsittelymarkkina on mielenkiintoinen markkina-alue tilaajayritykselle.

Työn tarkoituksena oli tukea kehittyville markkinoille luotavaa uutta liiketoimintaa. Diplomityössä oli yksi tutkimuskysymys ja yksi operatiivinen tavoite. Tutkimuskysymys pyrki vastaamaan kysymykseen, miten asiakkaiden päätöksentekoprosessi voitaisiin ottaa huomioon liiketoimintamallien kehityksessä. Tämä tutkimuskysymys pyrki ottamaan huomioon diplomityön malliluonteen tulevaisuuden kannalta. Operatiivisen tavoitteen vastaus pyrki vastaamaan kysymykseen, mitkä olisivat ehdotetut teknologiakonseptit ja investointivaihtoehdot Omanin jätteenkäsittelyyn. Tämä tavoite pyrki ottamaan huomioon ratkaistavan yksittäistapauksen, Omanin jätteenkäsittelyn ongelmat, ja tarjoamaan niihin konkreetteja vastauksia.

Omanin jätedataa analysoitiin MS Excelissä ja tämän analyysin perusteella luotiin viisi erillistä maantieteellistä keräilyaluetta. Tämä keräilyratkaisu kattaa yli 98% koko Omanin rekisteröidystä ei-vaarallisesta jätteestä. Kolmen suurimman keräilyalueen osalta tutkittiin seitsemää ja kahden pienimmän osalta kahta vaihtoehtoista teknologiakonseptia jätteen hävittämiseksi. Vertailu perustui taloudellisiin kannattavuuslaskelmiin sekä asiakkaan päätöksenteon simulointiin hyödyntäen laskennallista usean kriteerin päätöksentekotyökalua. Taloudelliset tunnusluvut toimivat yhdenlaisena syötteenä tälle laskennalliselle päätöksentekotyökalulle. Tunnuslukujen lisäksi kerättiin iteratiivisesti kolmessa eri vaiheessa abstraktimpaa tunnistettua tietoa asiakasarvosta ja eri teknologiakonseptien kyvykkyyksistä. Abstraktimman tiedon tunnistamisessa hyödynnettiin muun muassa tutustumista paikalliseen alueeseen sekä ammattilaisten ryhmätyöpajaa, jotta tunnistettu tieto olisi abstraktista luonteestaan huolimatta mahdollisimman luotettavaa.

Asiakkaan päätöksenteon simuloinnin tulokset suosivat teknologiavaihtoehtoa 2 jätteen hävittämiseksi. Liiketoimintamalli luotiin tämän jälkeen hyödyntäen simulaatiossa kerättyä ja rikastettua tietoa. Liiketoimintamallin esittämisen ja laatimisen työkaluna käytettiin Business Model Canvasta. Lopuksi työssä selvennettiin ja kuvailtiin vielä työn malliluonnetta tulevaisuuden kannalta, kuinka työssä esitellyt työkalut palvelevat liiketoimintamallien luontia tulevaisuudessa.

PREFACE

Working on this extremely interesting thesis topic began, on my part, in the beginning of June 2015. The journey was from the beginning to the end fascinating and filled with new learning experiences. I had many mentors to support me and I can honestly say that the thesis project enlarged my understanding about business life a great deal. I was also able to travel to see the Sultanate of Oman and to receive the actual hands on experience which, that being said, might not always be the most pleasant experience when dealing with wastes.

I would like to thank all the relevant parties involved in my thesis project. First of all, prof. Suomala and DSc. Korhonen, who were my examiner and supervisor, respectively, from the university. I also owe a lot to Mr. Lepomäki, Mr. Hakanperä, and Mr. Jarkko, who all have been guiding me and devoting generously their personal time to this project. I would also like to thank all the other colleagues and parties involved. Lastly, I want to thank my family members for their support, countless hours of revision reading, good food, and reminding me that there is life outside the thesis project as well.

Tampere, 17.12.2015

Kristian Batista

CONTENTS

APPENDIX 6: BMC

LIST OF FIGURES AND TABLES

LIST OF SYMBOLS AND ABBREVIATIONS

SRF	Solid Recovered Fuel
MSW	Municipal Solid Waste
NPV	Net Present Value
FMEA	Finnish Material Efficiency Alliance
EU	European Union
GDP	Gross Domestic Product
CIA	Central Intelligence Agency
EBIT	Earning Before Interests and Taxes
ELECTRE	ELimination and Choice Translating REality
PROMETHEE	Preference Ranking Organization METHod for Enrichment of Evaluations
AHP	Analytical Hierarchy Process
GAIA	Geometrical Analysis for Interactive Aid
CHP	Combined Heat and Power
NCV	Net Calorific Value
PESTEL	Political, Economic, Social, Technological, Environmental, and Legal
PR	Public Relations
BAT	Best Available Technology
IRR	Internal Rate of Return
MS	Microsoft

1. INTRODUCTION

People produce waste as a side product to their daily life. The overall increase in standard of living has also raised the average amount of waste produced per capita. Since the amount of waste produced is building up on a rapid phase the waste is becoming a serious problem for humankind. Existing waste can also be considered as wasted resources, since the waste is usually stockpiled on landfills and is then left without purpose and only producing environmental and health hazards for the surrounding regions. However, the waste contains valuable materials which, when recycled and reused, could help to reduce the need for, for example, mining new minerals. Since the resources in earth are increasingly scarce, it is important to look for ways to reduce the amount of waste disposed and to take advantage of the valuable resources contained in waste.

The European Union has defined a waste hierarchy to regulate its member countries' waste related actions and thus to better protect environment (Waste Framework Directive 2008). In this waste hierarchy the highest priority is on reducing the overall amount of waste produced, then preparing the waste for reuse, recycling the waste, then using the waste to other purposes, mainly on producing energy, and last is the final disposal when no other mean of use or recovery is applicable. The preparing for reuse and recycling both advance circular economy, where valuable raw materials return to the supply chain and are reused rather than disposed. The use of waste in energy production means mainly the incineration where the thermal energy of the waste is captured to produce, for example, electricity. This is the last level in the hierarchy before final disposal, meaning that only the fractions of the waste that cannot be reused or recycled should go through this phase and what cannot be utilized here will end up in disposal.

The purpose of this thesis is to support market entry in emerging markets in case of waste utilization in Sultanate of Oman. This means that the current waste management of Oman is analyzed and possible development areas are identified. Then, a business model for waste management equipment and solutions provider is created in a way that the achievements in this thesis also function as a template for future business model creations for the same equipment and solutions provider. The research question is: how to take into account the customers' decision-making process in business model generation. This research question handles the different factors in customers' decision-making regarding the potential investments and how to take them into account and utilize them in creating the future business model for the selected market. The thesis has also an operative goal set for it. This operative goal is formed into a question: what are the proposed technology concepts and investment opportunities for treating waste in Oman. The solution of this operative goal takes into account the properties, amount and quality of the collected waste in different locations. The other aspect of this operative goal is the demand for different achieved outputs of different treating concepts. This is also affected by the general willingness to protect environment and thus to apply reasoning similar to waste hierarchy defined by EU. As an answer to the operative goal it is attempted to find optimal investment properties and options by taking into account the waste variables and parameters but also the different values of various stakeholders.

Regarding the subject of the thesis, the research question, and research scope of this text, the aim of this thesis is to provide answers to current questions of a supplier company by utilizing current known theoretical frameworks. Thus, the thesis does not aim to directly contribute to the literature by testing new hypotheses and deriving new theory from empirical research. Instead, from the theoretical perspective the thesis rather aims to testing existing theories and frameworks suggested by previous literature. The testing of these frameworks and theories then contributes to the literature by generating an application case of the utilized frameworks.

In this text the research question is solved by providing a template method by utilizing customer value identification and a customer decision-making simulation based on the value identification. In order to identify some of the customer value components that are location specific, a geographic collection solution needs to be created first. This geographic collection solution also sets some contours for the relevant technology alternatives per location. Thus, this phase influences also the solution to the operative goal. Based on the geographical collection solution, customer value identification and customer decision-making simulation, a list of technology concepts in order of favorability per geographical collection location is achieved. This outcome provides answers for the operative goal and gives also important insight for generating a business model by using the Business Model Canvas. The use of the phases of customer value identification, customer decision-making simulation, and use of Business Model Canvas is utilized to answer the research question and as a whole together with the documented template nature of the thesis, provide important support for market entry in emerging markets also in future by providing a clear process consisting of said methods and actual tools introduced in the text. This process is also illustrated in Figure 1 below.

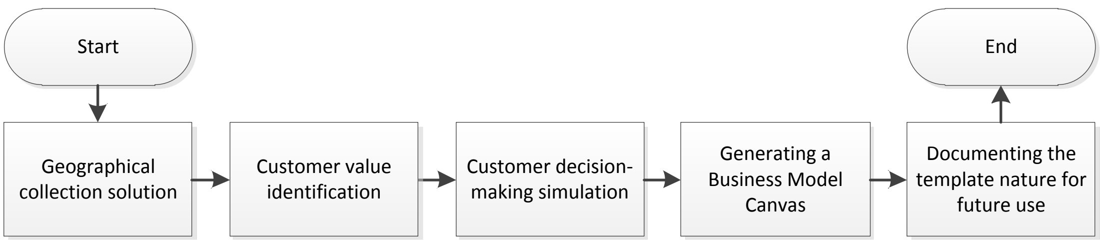

Figure 1. *Simplified flowchart of the thesis process*

The text is structured as follows. In second chapter, background for the thesis and current waste management situation in Oman is described. In third chapter, the relevant literature is reviewed to form a theoretical framework for the thesis. The fourth chapter introduces some processing technology alternatives for municipal solid waste. Fifth chapter presents the geographical collection solution that is later used in this thesis as a starting point for financial calculations, customer value identification, and customers' decision-making simulation. The sixth chapter analyzes the customers' decision-making and provides a simulated proposal of the selected technology alternatives in order of favorability for the customer. In seventh chapter the generation of the Business Model Canvas according to the previous proposal simulation is discussed. The eight chapter discusses the template nature of this thesis to function as a template for the future business model generation cases in the same supplier company. Lastly, in the ninth chapter, conclusions about the thesis are presented and discussed.

2. BACKGROUND

In this chapter general background about the subject of this thesis and Oman is presented. Motivation for the business model generation for Oman markets is discussed and the present state of waste management and general demographics in Oman are illustrated. Some reference figures and concepts from Finnish society and waste management are also presented to make the cases comparable.

2.1 Oman

Oman, officially Sultanate of Oman, has the population of roughly 3 287 000. Thus, in terms of population, it is of same scale though smaller than Finland, which has population of rough 5 477 000. This is important, since the amount of waste generated annually can be considered to depend, at least in part, of the population size. In terms of gross domestic product (GDP) Oman has a GDP (2014 estimate) of $163,6 billion and current estimated growth rate of 3,4% annually, whereas Finland has a GDP (2014 estimate) of $221,5 billion and current estimated annual growth rate of -0,2%. This means that the GDP per capita in Oman is roughly $44 100, while in Finland it is $40 500. (CIA 2015)

Petroleum industry plays a strong role in Oman's economy and exports, although Oman has been trying to reduce its dependency of fossil fuel industry by increasing its service and tourism industry (Harvard 2015). Still, for example, 100% of energy produced in Oman is produced via fossil fuels (CIA 2015). Thus utilizing waste in national energy production could help reduce the required fossil fuels in energy industry and release more of these resources for international export.

The population in Oman is focused on both northern and southern coast. In south, the population density is greatest in Salalah and this functions as the southern population center of Oman. In north, population is more evenly spread and there are numerous cities on the northern coast, for example, Muscat and Sohar. In north the mountain region inhibits the population from spreading more south and inland. In addition, majority of Oman belongs to the Rub' al Khali sand desert, also known as "the empty quarter", located in the southern Arabian Peninsula. This vast dry sand desert also causes the population to be centered on coastal regions.

Politically Oman has tried to remain neutral maintaining good relations to western countries as well as to other countries on Arabian Peninsula. For this reason, Oman has functioned as an intermediator between, for example, United States and Iran.

Majority of the population of the Oman are Muslims, belonging to the Ibadi School of Islam. Ibadi is a minor school of Islam compared to, for example, Shia and Sunni schools.

Mainly, Ibadi is the majority religion only in Oman and Zanzibar. Ibadi has some differences in opinions about the religion compared to more mainstream schools of Islam and in general Ibadi is considered to be conservative.

2.2 Present day waste management in Oman

At the moment, waste is treated in Oman mainly by landfilling. Some different methods for medical and healthcare waste and other special waste streams exist, but those streams are outside the scope of this thesis, as this thesis is focused on non-hazardous municipal waste and, in some extent, non-hazardous industrial waste as well. This is due to the reason that the company, for which the business model is generated for, operates on these segments of waste handling.

In Oman there are around 300 dumpsites. The number presented in municipal waste survey is initially 366, but later in the text it is noted that some of these aren't any more in operation (be'ah 2013). In one other source, there is stated to exist 317 official dumpsites (Said 2014). Thus, there is no accurate info over the true number, but the amount of active dumpsites is assessed to be around 100 in the waste survey (be'ah 2013). The technology level varies between the dumpsites, some of them being literally only dumpsites operating on very low volumes and a few of them being, in fact, well organized, planned, and engineered landfills operating on high volumes. On these engineered landfills the quality and composition of the waste is also monitored.

Oman is planning on constructing more engineered or sanitary landfill sites as an answer to the increasing waste problem. Also, the collection equipment is stated to be insufficient and outdated (Said 2014). On the other hand, the general opinion is to try to take also in account the environmental factors in waste management. Consolidating the waste management to a few well organized and environmentally sustainably constructed sanitary landfills would help to avoid environmental disasters caused by the poor waste management. On the other hand, landfilling, even when sanitary landfilling technology is used, does not necessarily result in end of waste state. Thus, the waste remains as waste in the ground for years and decades. Storing the waste does not give the society any advantage of the waste. However, it requires work, energy, land area, and still, it contains some risk for environmental disasters in future.

By the Royal Decree 46/2009, the responsibility of waste management is on Oman Environmental Services Holding Company (be'ah 2015). The Oman Environmental Services Holding Company has a brand name be'ah and thus it will later in the text be referred to as be'ah. In essence, be'ah owns all the waste produced in Oman and is the responsible party in disposing it properly and developing the waste management technology and concepts in Oman.

There are four landfills in Oman that are considered to be large in terms of volume and population served. Combined, these are estimated to serve 41% of all the population in Oman. In addition, there are 11 medium sized landfills. Combined together with the large landfills, these landfills are estimated to serve some 67% of all the population in Oman. The 26 small dumpsites serve additional 23% of the population. Thus, only 10% of the population are served by the smallest dumpsites, categorized as very small. (be'ah 2013)

One key note in the waste survey is that there is no existing system for recycling plastic bottles in Oman (be'ah 2013). For this reason, empty water and other drinking bottles usually end up in trash. When this is combined with the fact that the consumption of bottled water in Oman is high, the result is that the plastic concentration in the waste is relatively high. Incorporating a, for example, pant enforced recycling system like in Finland, could possibly help to decrease the amount of plastic landfilled (be'ah 2013). On the other hand, high plastic concentration in waste increases greatly its calorific value. This is due to the reason that the plastic has roughly the same calorific value as oil. In addition, the plastic does not absorb moisture and thus the more there is plastic in waste, the less there is room for moisture, which would lower the overall calorific value of the waste mass. This high calorific value waste would possibly enable high combustion efficiency and high overall electricity production efficiency.

2.3 FMEA

Finnish Material Efficiency Alliance, FMEA, is an alliance of companies offering waste and material efficiency technology and service. As a result, FMEA offers an integrated solution for waste management, utilizing as much of the potential in the waste in producing customer value as possible. Since there are companies representing several different technologies, FMEA waste management proposal can take into account various customer needs and requirements for waste management. The FMEA operational model is illustrated in Figure 2 below.

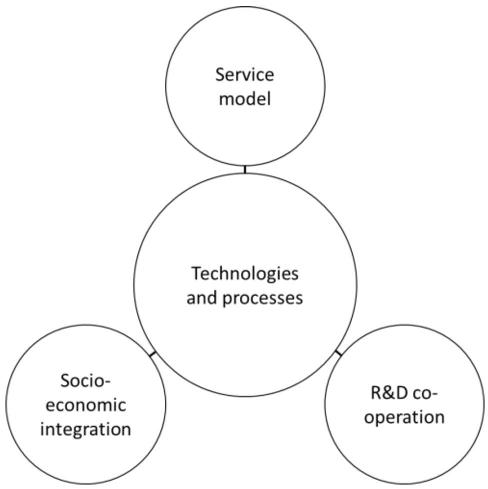

Figure 2. *FMEA operational model (adapted from FMEA 2015)*

FMEA aims to deliver also socio-economic integration, research and development co-operation and service in addition to the actual technology and process, which are physically delivered to the customer, as illustrated in Figure 2. This comprehensive package is designed to create more value for the customer by integrating the delivered technology into present processes and to ensure that the implementation of the waste management solution is comprehensive and not just the delivered technology or process. The comprehensive waste management solution is illustrated in Figure 3 below. (FMEA 2015)

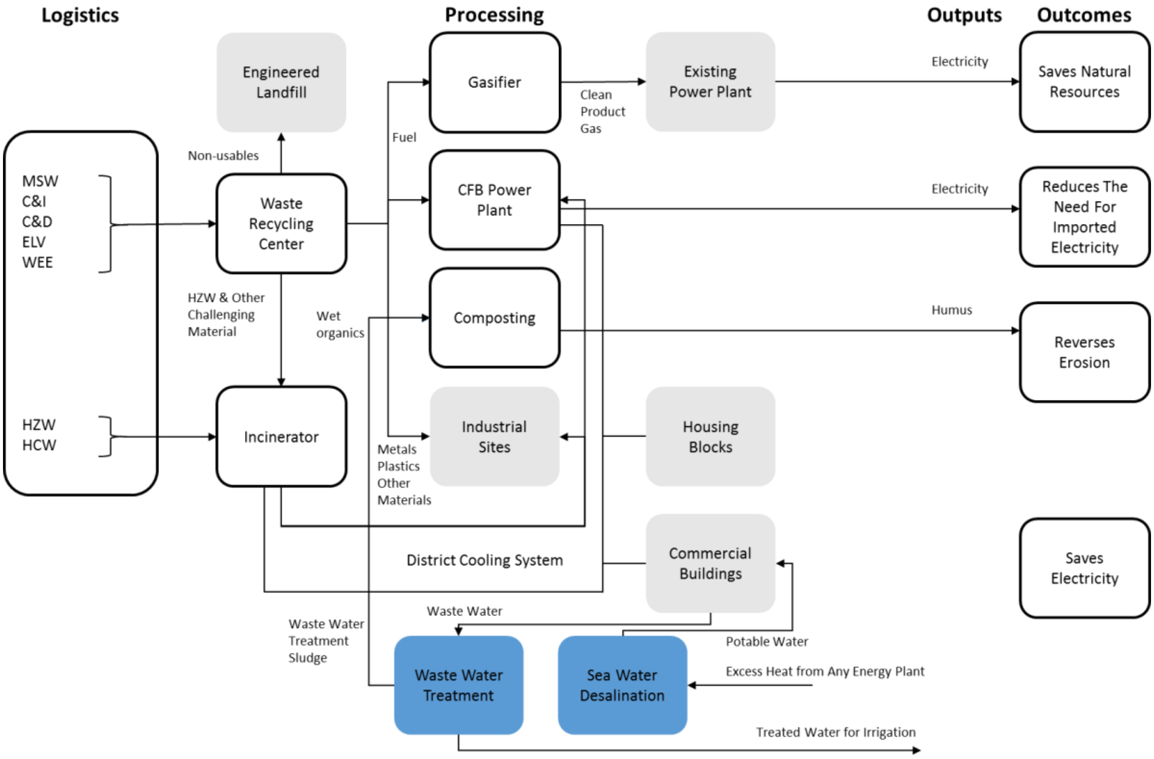

Figure 3. *FMEA waste refining concept (adapted from FMEA 2015)*

Originally, the idea for FMEA stemmed from the recognized high technology level of hazardous waste management in Finland. The potential for exporting of this technology and knowhow was understood and thus a consortium of relating companies was planned. However, later the potential for exporting also the technology and knowhow of non-hazardous waste management was identified and then added to the concept. This led to FMEA, an alliance of various material efficiency companies and technologies. As a result, FMEA can offer a comprehensive waste refining concept, as illustrated in Figure 3, with multiple beneficial final outcomes (FMEA 2015).

3. LITERATURE REVIEW

This chapter presents a brief literature review over the relevant literature on customer value, decision making and business model canvas framework. Understanding customers' decision-making and what they value and why is important regarding this thesis, since the objective of this text is to provide a business-development template to support market entry in various situations. For this purpose the customer value and their decision-making process are assumed as a vital variables. The business model canvas framework is introduced to the reader in the beginning of this chapter in order to pave the reasoning for the other two selected literature review sections. Finally, a synthesis over the conducted literature review is discussed.

3.1 Business Model Canvas

Business Model Canvas is a simple and graphical method to illustrate and to present the company's business model (Osterwalder et al. 2010). It is developed by Osterwalder and Pigneur and presented in, for example, a book called Business model generation: A Handbook for Visionaries, Game Changers, and Challengers, where they are the two main authors (Osterwalder et al. 2010).

Business Model Canvas constructs of nine basic building blocks: Key Partners, Key Activities, Key Resources, Value Propositions, Customer Relationships, Channels, Customer Segments, Cost Structure and Revenue Streams (Osterwalder et al. 2010).These blocks are presented on a canvas in a graphical style. These basic blocks are separately discussed more below.

Customer Segments block refer to the selection of the served customer segment. In their book, Osterwalder et al. identify five different categories of customer segmentation: mass market, niche market, segmented, diversified, and multi-sided platform. Mass market aims to create general value for as many customers as possible, and doesn't make real effort to craft its value proposition for any specific customer segment. Vice versa, a supplier in niche market does the opposite, and tries to create a fulfilling value proposition for a very specific, possibly even small, customer segment. On the other hand, focusing and delivering superior value for a special group may enable the supplier to charge premium prices and thus be even extremely profitable. Supplier operating by segmenting markets is something in between these two previous models. Segmenting helps the supplier to identify the area and customers in the market where they are willing to operate and to provide value. Segmenting can be done, for example, by identifying slightly differing needs and demands in the total market or by geographically or by some other variable. Diversified market segmentation leads the supplier to serve two fundamentally different customer segments. Osterwalder et al. provide an example of this, where they mention Amazon.com, which has begun to serve Web companies in addition to its previous business-to-commercial ecommerce platform. The last mentioned, multi-sided platform means that the provider provides a platform which needs both content providers and content users. An example of this could be, for example, gaming consoles. The console manufacturer provides the hardware platform and may provide some software content. However, additional content developers are needed, but also customers to use the content. The more the platform has users or content providers, the more attractive the platform is to the other one. (Osterwalder et al. 2010)

Value Propositions is the next basic building block in Business Model Canvas. Customer value and value propositions are discussed later this text and thus they are only quickly mentioned here. However, it is vital for the supplier to identify the key value components regarding the selected customers or customer segments. In their book, Osterwalder et al. list some possible sources of value as an example. These are: newness, performance, customization, “getting the job done”, design, brand/status, price, cost reduction, risk reduction, accessibility, and convenience/usability. (Osterwalder et al. 2010)

Channels building block describes, how the created value is delivered to the customer. In general, Osterwalder et al. divide channel types in two categories: own and partners’. These can then be divided into direct and indirect channels. For an example, own web sales portal can be considered as own direct channel, whereas selling in partner owned stores could be considered as partner owned indirect channel. Important aspects regarding the channels are also communicating with the customers thus increasing their awareness of the value proposal and providing aftersales operations, such as service and support. (Osterwalder et al. 2010)

Customer Relationships block answers to the problem of how the relationship between customers and the company is organized. In their book, Osterwalder et al. list some examples of possible co-existing customer relationship models. These are personal assistance, dedicated personal assistance, self-service, automated service, communities, and co-creation. For example, dedicated personal assistance, assigning a dedicated customer representative for a specific customer, may be relevant for business-to-business supplier serving a large customer. On the other hand, some hotels operate on self-service principle, providing the customer with a key code to enter to the reserved hotel room and the customer may never encounter a customer service personnel during their stay but even the reservation and payment may be automated through online portal. (Osterwalder et al. 2010)

Revenue Streams define from where and how the company is receiving revenues. In general, there is two types of revenue streams: transaction revenues and recurring revenues. The first results from a one-time transactions, for example, when customer purchases a device from the supplier. Then the customer pays for the device, for example, in the store or via internet, for once, after which the supplier delivers the device for the customer and also giving up the ownership of the device to the customer. On the other hand, recurring revenues may result, for example, from automated subscription fees to a software or from regular aftersales service and maintenance operations. (Osterwalder et al. 2010)

Key Resources basic building block contains the information about the important key resources needed to create the value in the value proposition and also communicate, deliver, and capture the value. Such resources can be tangible or intangible, human, intellectual, physical or financial, whatever the company needs in its key operations. For example, for a specialist consulting company, human and intellectual resources are important, but they might not be as dependent on physical resources, such as, machinery or office space. On the other hand, for a bulk industrial supplier, the machinery and facilities may be very important resources, when research and development related resources may not be as important. (Osterwalder et al. 2010)

The Key Activities building block contains the information about what the company does and needs to do in order to communicate, create, deliver, and capture value. These activities can include, for example, production and problem solving, but also services and supply chain management. All the important key activities the company performs should be mentioned here. (Osterwalder et al. 2010)

Key Partnerships include the important partnerships with specific stakeholders. For example, alliances for strategic reasons, joint ventures, and cooperation between competitors. Relationships can aim to, for example, reduce the need to perform certain activities that aren't company's key activities or core competence. Relationships can also aim to reduce risks or acquiring certain resources. (Osterwalder et al. 2010)

Finally, the Cost Structure building block states how the costs are generated from operation. The nature of the business model can steer it to more cost- or value-driven direction. For example, if the customer value is mainly derived from low costs and thus the whole value proposition is built around it, then the whole business model should be cost-driven. In this case, knowing the cost structure of the business model at hand is very critical and can lead to even further development and minimization of costs. (Osterwalder et al. 2010)

Below in Table 1 is a table that illustrates the Business Model Canvas adapted from Strategyzer (2015). The template nature and that it is applicable to both designing and presenting the company's business model in a graphical manner, can clearly be seen from the business model canvas.

Table 1. *Business Model Canvas (adapted from Strategyzer 2015)*

Key Partners	**Key Activities**	**Value Propositions**	**Customer Relationships**	**Customer Segments**
- Who are our key partners? - Who are our key suppliers? - Which Key Resources are we acquiring from partners? - Which Key Activities do partners perform?	- What Key Activities do our Value Propositions require? - Our Distribution Channels? - Customer Relationships? - Revenue Streams?	- What value do we deliver to the customer? - Which one of our customer's problems are we helping to solve? - What bundles of products and services are we offering to each Customer Segment? - Which customer needs are we satisfying?	- What type of relationship does each of our Customer Segments except us to establish and maintain with them? - How are they integrated with the rest of our business model? - How costly are they?	- For whom are we creating value? - Who are our most important customers?
	Key Resources - What Key Resources do our Value Propositions require? - Our Distribution Channels? - Customer Relationships? - Revenue Streams?		**Channels** - Through which Channels do our Customer Segments want to be reached? - How are we reaching them now? - How are our Channels integrated? - Which ones work best? - Which ones are most cost-efficient? - How are we integrating them with customer routines?	
Cost Structure - What are the most important cost inherent in our business model? - Which Key Resources are most expensive? - Which Key Activities are most expensive?			**Revenue Streams** - For what value are our customers really willing to pay? - For what do they currently pay? - How are they currently paying? - How would they prefer to pay? - How much does each Revenue Stream contribute to overall revenues?	

In summary, Business Model Canvas is a simple template tool to illustrate, design, and present a company's business model in a graphical and intuitive manner. The template nature ensures, that all the important factors regarding business development are considered, at least in some depth. Some business models can, of course, be more focused on certain specific areas in the business model canvas, but even in those situations all the factors in the template should still be considered in some depth to provide a comprehensive, solid, business model to function as basis for actual business operations.

Business Model Canvas has also received some critique. For example, Kraaijenbrink (2012) criticized the Business Model Canvas for it disregards the company's strategic goals as all companies do not aim to maximize the profits, the weighing between the different components is unbalanced, and it does not take competition into account. However, in the case of applying the Business Model Canvas in this thesis and company is well established. The company’s strategy is not in contradiction with the Business Model Canvas, as the company is inclined into doing profitable business. The Business Model Canvas for the company will adapt more or less the business the company does already. Thus the Business Model Canvas will be made for a specific geographical market area adapting the normal business methods of the company. This also ensures that the competition is already taken into account in the company’s business and thus also in the Business Model Canvas created.

3.2 Customer value

In this text the concept of customer value is understood as the value that customer receives, thus, as customer-perceived value. This customer value is becoming increasingly interesting and important element in business management and marketing since it can be argued that it is central for, for example, competitive advantage (Salem Khalifa 2004), and thus for the entirety of business management.

Customer value is fairly extensively researched area in management literature. Due to this comprehensive research concluded there is also broad amount of different definitions for the actual customer value. In this text, however, the definition used by Töytäri et al. (2015) for the customer value is adopted. In their text Töytäri et al. define customer-perceived value as follows: “*Customer-perceived value is the difference between perceived benefits received and perceived sacrifices made by a customer. Both benefits and sacrifices are multi-dimensional concepts, combining operational, strategic, social, and symbolic dimensions of value*” (2015, p. 54). Salem Khalifa (2004) divides the customer value definitions into three main categories which are value components models, utilitarian or benefits/costs ratio models, and means-ends models. The selected definition by Töytäri et al. is located well in the utilitarian models and is generally in line with other definitions in literature located in the same category, although it also takes into account the multi-dimensional nature of both benefits and sacrifices as described in the second sentence in their definition for customer value. This definition is also illustrated in Figure 4, where the customer-perceived net benefits is considered to include also any costs and sacrifices the customer faces when obtaining the benefits, except the actual purchase price (Töytäri et al. 2015).

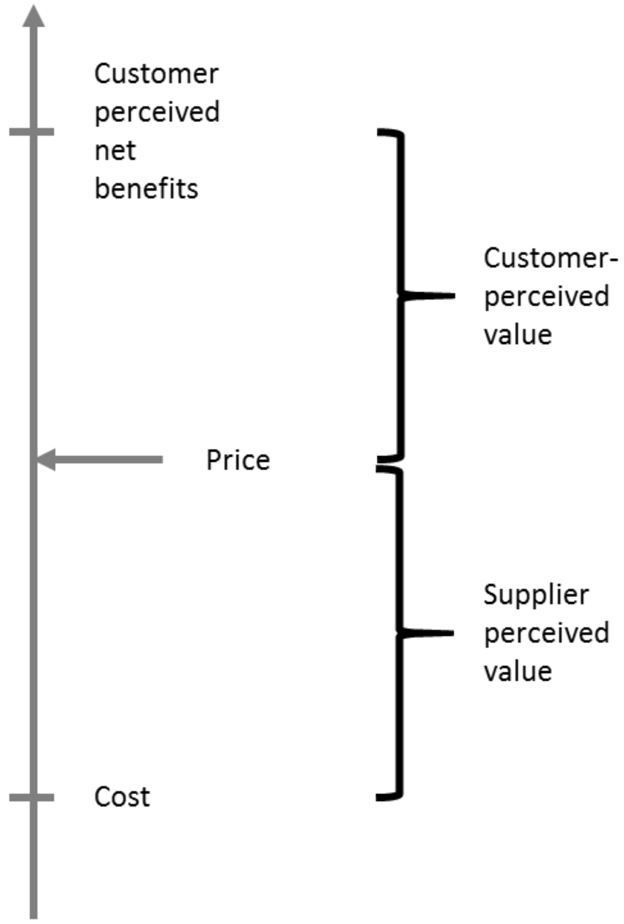

Figure 4. *Customer value as a product of net benefits and purchase price (adapted from Töytäri et al. 2015, p. 55)*

Understanding the customer value and net benefits is crucial for the companies. However, even though the importance of the understanding of the customer value is well identified, the companies' capability to utilize it to their benefit is limited due to the difficulties in actually demonstrating the value to the customer (Keränen 2014, p. 1).

Thorough understanding of the customer value can be utilized into, for example, conducting value-based pricing. In value-based pricing the purpose is to set the offering's price so that the value would be shared between the customer and supplier in some manner that is suitable to both parties. This is discussed in more detail in chapter 3.1.4 Capturing value. Other key purposes for understanding the customer value are, for example, value based selling (Töytäri & Rajala 2015; Töytäri et al. 2011) and defining and reconstructing value propositions (Wouters & Kirchberger 2015; Anderson et al. 2006). These are also discussed in more detail in chapters 3.1.3 and 3.1.4.

3.2.1 Identification of the value

Product-centric view of the market is common for the suppliers. This may be, for example, due to the company's history, where the company initially invented a key product or service to fulfill a specific need on the market that was still unfulfilled (Kothari & Lackner 2006). This causes the company view the market from inside to outside, when company is making products and pushing them to market expecting the market to accept them (Kothari & Lackner 2006). As this is not very sustainable principle, companies should try to instead view the market outside-in, meaning that they should consider the needs they are capable of fulfilling now and in near future and to focus on developing offerings according to that information (Kothari & Lackner 2006). This also helps the company to understand the differences in how the customers take benefit from the company's market offering (Kothari & Lackner 2006).

In their text, Anderson & Narus (1998) present a method to assess and identify value by using customer focus groups. This method consists of several different focus group meetings where the focus group is participating in a survey and discussion about how they would use a certain product or offering and what would they be willing to pay for it. Another method presented by Anderson & Narus (1998) in their text is field value assessment. This method means gathering value data firsthand from the customers and for this purpose a value assessment team consisting of various professionals, including sales, product, and marketing specialists, is gathered (Anderson & Narus 1998). The team should generate a comprehensive list of the value elements and then estimate the worth of each element for the customer. The worth can be in monetary terms, but also in qualitative form, in case the value is difficult to express in monetary terms. The assessment can be done by, for example, placing a team member or members into the customers' organizations and to let them participate and to observe the daily routines in the customers' organizations. This requires also for the customer to participate and to give access for the supplier to conduct research and analysis. The prospect of the research's results, low or zero costs, and potential to benchmark with other customers should be enough to encourage given customers to participate into the supplier's field value assessment research. (Anderson & Narus 1998)

On the other hand, Keränen & Jalkala (2013a) argue in their text that customer value assessment is more of a continuous process than a discrete project happening in a specific timeframe. This means that the customer value assessment should be understood to happen before, during, and even long after the delivery to the customer is done. The customer value assessment should also cross organizational boundaries, involving specialists from various organizational functions (Keränen 2014, p. 46; Keränen & Jalkala 2013b). This is to decentralize the customer value assessment and not to focus it only, for example, the sales representatives. The decentralization through involving multiple organizational functions might help the company to identify even the more unapparent value components.

Identifying what elements really are worth and which elements truly provide value for customers gives supplier more concrete suggestions of how to allocate sparse resources to optimize the value proposition. For example, leaving some value elements out of the offering in case they are, in reality, worthless for the customers may save suppliers costs. Reducing costs on the other hand can allow lowering the total purchase price for the customer while in reality increasing both parties' margins. Thus the thorough understanding of what the customer actually values may increase the supplier's capability to deliver superior value. In their text Anderson & Narus (1998) provide an example of leaving a value element out of a chemicals supplier's customer's offering, resulting in lower costs and in the end, superior value creation and increase in customer's profitability for the supplier.

3.2.2 Quantification of the value

Expressing the value in monetary terms has numerous positive effects. Quantifying value propositions enables decision makers to easily and rapidly compare them with each other. Also the realized monetary value of a value proposition is in most of the cases, at least in businesses, the whole reason for purchasing an offering. In their text of a value based selling Töytäri & Rajala (2015) list five methods how expressing value in monetary terms may bring the proposition closer to a stakeholder. These methods are: *"(1) influencing the stakeholder's desired value conception, (2) adapting to the resonating measure of economic business impact, (3) selecting value elements based on salience, differentiation, and impact, (4) using relevant and quantified case stories as a source of motivation, and (5) aligning the solution proposal for the stakeholder*" (Töytäri & Rajala 2015, p. 107). Wouters & Kirchberger (2015) also support quantification by arguing that quantification leads to a very specific and exact language and means to discuss about value. However, Anderson & Narus (1998) mention in their text that some social elements of value can be left out from quantification. This is, for example, due to the difficulty to quantify such value elements. For example, a value from increased level of comfort in working environment could be very difficult to quantify. It can be argued that the increase in comfort in working area is linked to the, for example, productivity or creativity, but to actually prove how much this has monetary effect in the company's annual profit might be extremely challenging. The problem could be attempted to solve by setting a baseline and a following period and then compare the results from the following period to the baseline, but even this can be complicated. The initial baseline could be selected wrongly or even the results could be compromised, since the following period could have some kind of mental effect on the organization. Paradoxically, while the value received from the increase in the level of comfort could end up being extremely difficult to assess and quantify, most likely the costs involved in making the increase in the level of comfort happen could be relatively easy to quantify, as those are most likely costs from design hours, purchasing materials and assembly costs. For these reasons those more intangible and unquantifiable value elements can be discussed in a qualitative manner and thus still utilize them in the favor of expressing the value proposition to the customer. On the other hand, Töytäri & Rajala argue that even the less-tangible value elements may be quantified. They also provide example of actions increasing safety, which is a perceived probability distribution of random unfavorable scenarios and thus a very intangible value element, resulting into lowering insurance premiums and thus into quantifiable value (Töytäri & Rajala 2015).

In their text Töytäri & Rajala (2015) suggest, that identifying relationships between value elements and their key performance indicators, such as revenue increase or reduce in total cost of ownership, is a prerequisite for value quantification. After these elements and their relationships have been identified, value quantification can be executed. Töytäri & Rajala also present methods for this quantification, such as comparing two alternative proposals or the proposal with current situation (Töytäri & Rajala 2015). This is also supported by Wouters & Kirchberger, as they also suggest that: "*Customer value is best understood relative to the next-best alternative, rather than absolute*" (2015, p. 57).

Wouters & Kirchberger (2015) also argue in their text, that quantifying customer value doesn't only result in better understanding of the value of the current offering, but in fact these calculations will provide more deeper insight and likely will also have an effect on the products and services in the offering itself. This is due to a fact that for a company to produce actual value quantification, it is forced to look at its offerings from the customers' perspective, from the outside-in perspective, as discussed earlier, and this may result into increased insight and new ideas and eventually affect the whole offering (Wouters & Kirchberger 2015).

3.2.3 Communicating the value

Identifying the essential value elements and being able to create that value and thus fulfill the selected customer needs on the market is not alone enough. The customers must be made aware of the value potential the supplier carries. Superior communicating of the value is a cornerstone in, for example, value based selling. Communicating the identified value in the most efficient way will, for example, increase the supplier's potential to acquire new customers and to reduce customer churn, both of which have a positive impact on the total profitability of the company.

Communicating the value to the customer may not always, however, be as simple as describing all the value potential to the customer. To effectively communicate value Anderson & Narus (1998) suggest creation of value-based sales tools. These tools can be, for example, documented cases of realized customer value, value case histories (Anderson & Narus 1998). Providing actual realized history data of a certain value proposition may aid the company to demonstrate the true value potential of the proposal. Töytäri et al. (2011) also support this importance of providing credible reference of realized value. In his text, Keränen supports the documentation of the realized customer value as well (Keränen 2014, p. 57). Keränen also mentions that the collected customer case histories may help the company to benchmark their offering by accumulating the knowledge over the customer value (Keränen 2014, p. 57). Thus, the documented customer cases do not only serve as the tool for communicating and proving the customer value to the customer, but the documentation functions also in benefit for further development of the offering.

Another method for demonstrating and communicating value for customer that Anderson & Narus (1998) address in their text is spreadsheet software applications. The supplier may develop such tools and utilize them on sales managers' laptops in real time together with customer, on-site, and iterate with different numerical values for predefined variables (Anderson & Narus 1998). Customer may also give their input and estimates for certain variables and see the results in value estimates immediately. This kind of value consulting can be a strong tool in vale-based sales and value demonstrating, but achieving this requires precise understanding of the value proposition and the quantifying of this proposition. As previously mentioned, all value elements may not need to be quantified and thus included in numeric form in the spreadsheet software applications. Instead they can be included in more qualitative discussion.

Besides the methods, the focus of communicating the value to the customer is also important. The question is, what value elements and value realization to communicate to the customer? The most obvious solution is of course to communicate all value elements as they are all positive to the customer. However, as previously mentioned, the value is best understood as comparisons between alternatives (Wouters & Kirchberger 2015). In their text Anderson et al. discuss more deeply the focus of communicating value (Anderson et al. 2006). They identify three main categories for the extent of focus in the communicating value. These categories are: all benefits, favorable points of difference and resonating focus (Anderson et al. 2006). Below in Table 2 is a comprehensive summary of the different categories that Anderson et al. (2006) identified in their text.

Table 2. *Three different focus levels (adapted from Anderson et al. 2006, p. 6)*

Value proposition	**All benefits**	**Favorable points of difference**	**Resonating focus**
Consists of	All benefits customers receive from a market offering	All favorable points of difference a market offering has relative to the next best alternative	The one or two points of difference (and, perhaps, a point of parity) whose improvement will deliver the greatest value to the customer for the foreseeable future
Answers the customer question	"Why should our firm purchase your offering?"	"Why should our firm purchase your offering instead of your competitor's?"	"What is most worthwhile for our firm to keep in mind about your offering?"
Requires	Knowledge of own market offering	Knowledge of own market offering and next best alternative	Knowledge of how own market offering delivers superior value to the customers, compared with next best alternative
Has the potential pitfall	Benefit assertion	Value presumption	Requires customer value research

As previously described, the "all benefits" communicates all the benefits to the customer. This option also requires the least amount of knowledge and understanding of the value proposition (Anderson et al. 2006). By definition, the favorable points of difference benchmarks the offering to the next best alternative and focuses on communicating the value of those elements, that are superior compared to the next best alternative. This method requires more understanding of the value proposition and of the rivaling propositions and is thus much more complex and consuming to implement. However the results are more favorable since the method highlights to the customer, why they should select the supplier's offering instead the next best alternative. (Anderson et al. 2006)

The last mentioned method or category, resonating focus, focuses only on one or two value elements (Anderson et al. 2006). Those elements are usually favorable points of difference, but can also include a point of parity (Anderson et al. 2006). The most critical factor is that the elements to which the communication focuses are elements which delivers the greatest value to the customer (Anderson et al. 2006). The point of parity can be, for example, purchase price, if the customer is very price sensitive. The supplier can demonstrate, that their offering is not more expensive than the next best alternative. Besides that the supplier may demonstrate one or two points of difference, which produce the most value to the customer. In their text, Anderson et al. mention as an example for a point of difference a possibility to link remote offices to project execution (Anderson et al. 2006).

The lastly mentioned resonating focus method is in line with the analysis presented by Keränen & Jalkala in their text. They argue, that companies should strive to build brands around the key capabilities in customer value (Jalkala & Keränen 2014). These capabilities should in turn be aligned with the customers' goals (Keränen 2014, p. 58; Jalkala & Keränen 2014).

In summary the literature seems to agree, although in different terms, that the communication of the value is as important as understanding and being able to create it. The communication is most effective when it is credible, documented, based on historical data, and presented as comparisons between alternatives. The selection of focus is also important. The supplier may choose to highlight only the most important value elements in their offering.

3.2.4 Capturing the value

The supplier needs to capture a share of the value created. This, in general, means sales revenues and making profitable business on delivering value to the customers. As previously described and illustrated, the revenue comes, for example, from the sales price and possible other transactions, such as subscription fees. Value based pricing is one of the three basic pricing methods, the remaining two being cost-based pricing and competition-based pricing (Hinterhuber 2008). The main idea in value-based pricing is that the customer and supplier share the created value in some manner. The dividing boundary in sharing is the sales or purchasing price. The basic principle is that the price is set above the supplier's costs to ensure profitable business and below customers' total net benefits, so that customer's perceived value would also remain positive. This is illustrated in picture 1, previously in this chapter.

Pricing plays also an important role in suppliers' profitability. According to Hinterhuber (2004), all other variables remaining unchanged, only 5% increase in price increases EBIT by 22%. This is because, when operating on profit, all increases in price are immediate extra to the profitability. Thus, correct pricing ensures that the supplier does not sell for too low and on the other hand, operates on a sustainable price level compared to the value delivered.

Hinterhuber (2004) provides a complete framework for implementing value based pricing in their text. This framework consists of the following steps: define pricing objectives, analyze key elements of pricing decisions, select profitable price ranges, and implement price change. The analyzing of key elements of pricing decisions is further divided into three separate segments, customer, competition and company itself. For the customer a value analysis should be concluded. The competition is analyzed in the market and the company must also be aware about its costs, volumes and profits (Hinterhuber 2004). On the other hand, Töytäri et al. (2015) note that the usual barriers to value based pricing lie in the cost-based pricing, which still is more or less the standard in pricing, at least on some industries. Customer's willingness to pay is heavily affected by the perception of a fair price. The supplier's costs usually function as reference point for a perceived fair price. Töytäri et al. even give an example of a case, where the customer declined an offer since it considered it to be too good deal for the supplier (Töytäri et al. 2015). However, Shipley & Jobber (2001) note that the cost-plus method may not always result in a fair price for the customer, since the fairness also depends on the perceived benefits. It is thus important to demonstrate clearly the value and benefits to justify the price, especially if the customer perceives the cost-based price as a reference point for the fair price. Töytäri & Rajala provide an example comment from a senior manager supporting this in their text, arguing that: "*By showing value, we can charge steep cost-based prices*" (2015, p. 108).

Pricing is not, however, the only affecting variable in capturing value. Kothari & Lackner (2006) present a three dimensional framework, called "The Value Cube", in their text. The cube's axis are customer profitability, share of wallet and number of customers, respectively (Kothari & Lackner 2006). They argue, that as most of the companies only focus on optimizing their business on one or two of these axis, the companies are missing a great overall potential on their market (Kothari & Lackner 2006). Whereas the pricing may affect the customer profitability, the companies should also consider increasing their share of the total spending of a specific customer and the total market share.

One interesting different idea for capturing value is suggested by Keränen (2014) in his text. Keränen argues, that by focusing on customer value assessment the company might have developed a necessary capability to offer customer value assessment as an external service as well and thus increase their service business (Keränen 2014, p. 58).

In summary, the pricing is an important factor in capturing a portion of the delivered value. The price is influenced by the suppliers' costs and the customers' willingness to pay. The willingness to pay in turn is a product of multiple components, including the net benefits and, for example, a factor of what is considered as a fair price, which in turn is usually dependent of supplier's costs. However, the pricing is not the only method to affect value capturing, but the company should also focus on increasing the overall share of wallet per customer and the total market share.

3.3 Decision making

Decision making is an important aspect since the building of the business model assumes in this case some investments by customer. To assess the potential investment prospects, it is necessary to first understand the decision-making which dictates the investments. Since the situation is different in every market entry, the same assumptions about decision-making and possible tools used in this case study may not be valid. Thus, to provide a general template for creating a market entry aiding business models, it is important to introduce the fundamentals of decision-making and some tools available to use in further business model generation processes, so that proper ones may be selected in each future scenario.

This chapter is divided in two parts. The fundamentals of individual's decision-making under uncertainty is introduced in the first chapter. This introduction relies on prospect theory, developed by Kahneman & Tversky in their famous article *Prospect Theory: An Analysis of Decision under Risk* and utility theory. Introducing the fundamentals of decision-making is important, since the decisions are always made by humans in the end, even if the question was about large scale environmental or energy industry investments. Understanding the basic decision-making may help to avoid the standard pitfalls of human decision-making. On the other hand, understanding customers' decision-making may aid in creating and communicating an appealing business model. The second part discusses aiding decision-making by quantitative means. This includes a narrow introduction of a few tools developed for this use and general terms and framework of this area. The two selected quantitative multi-criteria decision-making tool in this case, Weighted Sum Method and ELECTRE III, are then introduced more in depth to the reader. The tools were selected due to their simplicity, capability to multiple criteria, suitability to environmental and energy related decision-making and the need for only one decision-maker. These tools are also later in this thesis used to simulate customer's decision-making.

3.3.1 Prospect theory and human decision-making

In their text Kahneman & Tversky introduce a decision-making theory called prospect theory as a critique and alternative for the previous utility theory (Kahneman & Tversky 1979). The prospect theory aims to explain human decision-making under uncertainty or risky situations. Such decision-making situations could be, for example investment or money related decisions but, also other decision situations. As a reference, Kahneman & Tversky (1979) provide in their text multiple monetary examples, but also one regarding Russian roulette.

Prospect theory is a complex and relatively well adopted and extensively researched theory. For additional reading provided on prospect theory, one can look for texts by, for example, Barberis (2013), Kahneman (2003), Levy (1997), and Tversky & Kahneman (1992). However, the purpose of this chapter is to provide quick insight to the reader of the prospect theory to enable reader to comprehend the underlying fundamentals in human decision-making for the further analysis in this thesis and future business model creations.

There is a few important key assumptions in prospect theory, by which the prospect theory can be fairly rapidly summarized sufficiently for the purposes of this text. These are

1. Value is understood through relations and change, as gains or losses, not as a final state of, for example, wealth
2. The assessment of change requires a reference point
3. Losses are weighed more heavily than gains
4. Probabilities are understood as subjective weights, that have a quantum nature and are biased from mathematical probabilities (Kahneman & Tversky 1979).

These are more intuitively illustrated in Figure 5 and Figure 6, which represent value function and weighting function, respectively.

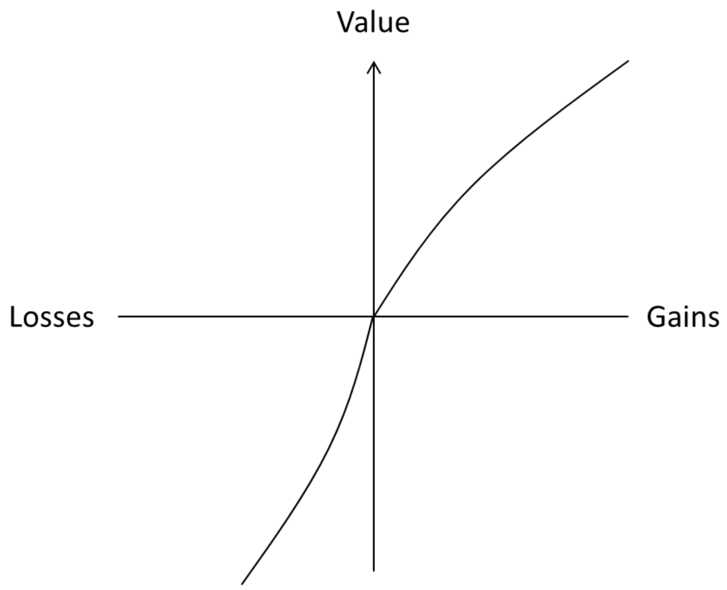

Figure 5. *Hypothetical value function (adapted from Kahneman & Tversky 1979, p. 297)*

As can be seen from Figure 5, the losses are typically weighted more heavily than the gains. Thus, the curve on the negative side is steeper, as the value is presented as a function of the losses and gains.

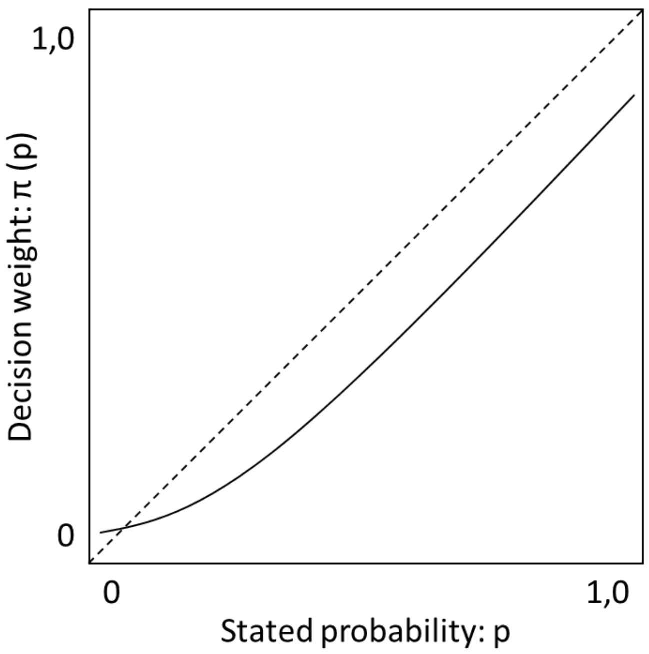

Figure 6. *Hypothetical weighting function (adapted from Kahneman & Tversky 1979, p. 283)*

Kahneman & Tversky (1979) argue, that the value is understood as relations or change, not as final state of the outcome. They provide an example, where change of 3°C is easier to distinguish from the change of 6°C rather than a change of 13°C from change of 16°C (Kahneman & Tversky 1979). This is due to the fact that the relative difference in change is bigger between 3°C and 6°C than between 13°C and 16°C, even though the absolute change is the same (Kahneman & Tversky 1979). They propose, that the same phenomena applies to monetary evaluation as well (Kahneman & Tversky 1979). This leads to the conclusion, that linear growth in outcome does not linearly increase the perceived value. Instead, the growth in perceived value resembles a concave arc on the positive side and as a convex arc on the negative side, as illustrated in Figure 5 (Kahneman & Tversky 1979). However, as the losses are weighted more than the gains, due to the risk aversion nature, the arc on the negative side is steeper than on the positive side (Kahneman & Tversky 1979).

To evaluate change, a reference point is needed (Kahneman & Tversky 1979). This reference point is typically the current state, for example, current wealth (Kahneman & Tversky 1979). Thus, the reference point is used to enable measure the realized change. One particularly interesting factor considering the reference point is that, according to Kahneman & Tversky, its position can be affected by presenting the situation differently. For example, by presenting the situation differently, a presenter can make the decision maker to understand how the things will go and this assumed result functions as a reference point instead of the current situation. Kahneman & Tversky (1979) provide a comprehensive example of this, where a professional weathers a slump better than his competitors. In this situation, the professional might consider the smaller loss that he suffered, compared to his competitors, as a win, instead of a loss (Kahneman & Tversky 1979).

Another interesting dimension in decision-making that the prospect theory takes into account is the subjectively experienced probability (Kahneman & Tversky 1979). Prospect theory includes a weighting function, illustrated in Figure 6 that is a subjectively experienced function to probabilities (Kahneman & Tversky 1979). This causes the experienced probabilities to differ from the mathematical probabilities. Typically humans over exaggerate small probabilities and a typical example of this is buying lottery tickets or insurances. On the other hand, Kahneman & Tversky (1979) introduce a term called subcertainty. By this term they mean, that other than for the probabilities that are not small and thus over exaggerated, typically the experienced subjective weight is lower than the mathematical probability (Kahneman & Tversky 1979). This is shown in the Figure 6 as a weighing function appearing below the linear mathematical probability. On top of those two main phenomena considering the weighting function, the subjective weighing of probabilities has also a quantum nature (Kahneman & Tversky 1979). This means, that for extreme probabilities in both near 0 and 1, the probability is considered as impossible or certain, respectively. This is due to the humans' lacking capability to understand extreme probabilities. This is shown in the Figure 6 as a discontinuity near values 0 and 1.

Human nature tries to also simplify the decision-making situations by both rounding and disregarding some alternatives. For example, if a probability of an outcome is near to 0.5, for example, 0.48, its probability might be understood as even. Same kind of rounding might happen for outcomes also. For example, if an outcome is near 1000, for example, 998, it might be understood as even 1000. Furthermore, very small probabilities and dominated alternatives are disregarded from the decision-making. (Kahneman & Tversky 1979)

When thinking intuitively, humans are also prone to use heuristic principles in their rapid decision-making (Tversky & Kahneman 1974). Heuristic principles are used to simplify the decision-making and they are usually quite important and beneficial. However, they can also lead to wrong conclusions and systematic errors. Tversky & Kahneman (1974) discuss three types of heuristics in their text. These heuristics are representativeness, availability, and adjustment and anchoring (Tversky & Kahneman 1974). In their text they prove that people use these kinds of heuristics in their decision-making and that the application of heuristics is not limited to laymen only, but that also trained scholars and professionals are subject to using such heuristics, when they think intuitively (Tversky & Kahneman 1974).

As a summary for human decision-making, people do not always follow the mathematically or objectively rational path in decision-making. Still, some general principles can be identified. For example, a prospect theory argues that people weight losses more heavily than gains. Also, outcomes are understood more as a change, not as a final state. People do not also understand probabilities as their mathematical probability, but instead as a subjectively experienced weights that are biased from the mathematical probabilities. Lastly, the chapter discussed briefly about the heuristic principles, which are used to simplify the decision-making process. It is important to understand these underlying factors considering normal human decision-making when creating a business model for new market entry and when the business model contains assumptions of customers making investments under uncertainty.

3.3.2 Quantitative decision aiding tools

Multi-criteria decision making is a decision-making method, where there is multiple different criteria for the decision to be made. For example, in case of choosing between machinery suppliers, the decision-maker might value not only costs, but also, for example, availability, reliability, brand image, and safety. Thus, all the defined criteria has to be taken into account while evaluating different options.

Choosing the criteria for the decision-making can be a result of many different factors. For example, local legislation or public opinion of the customers may set some criteria for the decision-making. On the other hand, customer value might also define some or even majority of the criteria. Customer value was previously discussed in this text for this very purpose.

Multiple-criteria decision-making aiding tools are developed to aid decision-makers to evaluate the different options according to the multiple different criteria defined by the decision-makers. One of the simplest and most used method is the Weighted Sum Method. In this method the performance of each alternative per criteria is simply multiplied with the criteria's weight and then the overall scoring of the alternative is calculated as the sum of these individual scores. Due to its simplicity it is easy to use in, for example, MS Excel and thus it is also widely used and the method is also easy to comprehend even without previous experience with multiple-criteria decision-making tools. For these reasons this tool is selected into this thesis to be used to evaluate the different alternatives and to compare the results of this method to another selected, more complex multiple-criteria decision-making tool's results.

As mentioned previously, there are also more complex and refined multi-criteria decision-making tools. Examples of these kinds of tools are Analytical Hierarchy Process (AHP), Preference Ranking Organization METHod for Enrichment of Evaluations (PROMETHEE), and ELimination and Choice Translating REality (ELECTRE) methods (Pohekar & Ramachandran 2004). The tools are typically numerical calculation tools to assess and, in the end, to provide a some kind of index or output for each option according to different initial values and predefined functions and algorithms specific for the tool at hand. The decision-maker can then utilize this output in their decision-making.

Defining the variables and their values used in each multi-criteria decision-making aiding tool is a critical phase in the use of these tools. These quantitative tools do not necessarily contain internal logic to correct human error in defining the variables and their values. However, the tool relies entirely on the human input in initial values and the formulas in the tool give results that it crafts directly from those initial values. This means, that any option can be rigged to appear as the most favorable choice by altering the initial values. Thus, the decision-maker must pay special attention in choosing the variables and defining their values for these tools.

Waste management and energy decisions are typically multiple-criteria decision-making situations. In their text, Hokkanen & Salminen (1997) utilize ELECTRE method, specifically ELECTRE III, to aid choosing of waste management system to Oulu region in northern Finland in early 1990’s. In their paper, Hokkanen & Salminen (1997) evaluate between 22 different options and have eight different criteria for the decision-making. Vego et al. (2008) utilize PROMETHEE and Geometrical Analysis for Interactive Aid (GAIA) in their text where they research municipal solid waste (MSW) management in Croatia. Vego et al. (2008) utilize seven different criteria and five different scenarios, where they give different values for criteria, to evaluate between 16 different options. In addition, also Karagiannidis & Moussiopoulos (1997) utilize ELECTRE III in their research for MSW management in Greece. Karagiannidis & Moussiopoulos (1997) evaluate five different options by using 24 different criteria in their decision-making.

AHP is a complex method, where the problem is divided into hierarchical process containing the actual objective on top, alternatives at the bottom and the criteria and sub-criteria in levels and sub-levels of the hierarchy (Pohekar & Ramachandran 2004). The method uses verbal scale where the elements on the same level are compared with each other and the comparison result transforms the comparison in numerical value between 1 and 9. Thus, a matrix is formed per each level. The matrix is used to calculate weight coefficient vector, which is then multiplied by the next level’s weight coefficient. In the end, AHP provides final weight coefficients for each alternative and the one with highest weight coefficient is considered the best alternative. On top of this, AHP also calculates an inconsistency vector, which tells how consistent the decision-maker was. Generally, if this index is higher than 0,1, the decision-maker’s consistency should be questioned and the evaluation of the different criteria and sub-criteria checked. (Pohekar & Ramachandran 2004)

By definition, PROMETHEE ranks alternatives according to selected criteria and their weights. In PROMETHEE alternatives’ are compared by criterion, then the difference of every compared pair is analyzed. If the difference is lower than the defined indifference threshold, the alternatives are indifferent in terms of the criterion at hand. If the difference is higher than the defined preference threshold, the other alternative is highly preferred in terms of the criterion at hand. After this is concluded for all the criteria and alternatives, weighted average of preference functions are calculated. According to these weighted average preference functions each alternative can be compared with each other as a whole and a ranking order can be defined. (Pohekar & Ramachandran 2004)

ELECTRE is a similar ranking method to PROMETHEE. Alternatives are compared according to criteria and their weight. However, ELECTRE has different thresholds which, for example, veto threshold, which justify disregarding some alternatives completely from the decision-making. ELECTRE also has preference and indifference thresholds to dictate whether one alternative is strongly preferred or over another or if one is insignificantly better than another.

In ELECTRE III, values for different alternatives on all criteria are first assessed. These are then scaled on a common scale, for example, between 0 and 1. Then the difference on the criteria value between all alternatives is compared. This difference is then analyzed through preference, indifference and veto thresholds. After this comparison the concordance index between alternatives is calculated, and this incorporates also the predefined weight or importance of the criteria. Levels of discordance are also calculated between alternatives. With these the ranking can be conducted. (Hokkanen & Salminen 1997; Figueira et al. 2005)

The ELECTRE III was selected as the other multiple-criteria decision-making tool to analyze the alternatives. The tool was selected due to its more refined and complex nature than the Weighted Sum Method, since it was previously used in energy industry decision-making, and since the input for this tool is similar to the input for the Weighted Sum Method.

There is also some software for these multiple-criteria decision-making aiding tools. In their text Figueira et al. (2005) mention software ELECTRE IS, ELECTRE III-IV, ELECTRE TRI, IRIS and SRF. These software are Microsoft Windows based and can be downloaded and installed for free. There is also an Excel based add-in by Jablonsky, called SANNA 2014, containing various different multi-criteria decision-making tools (Jablonsky 2014). This add-in can also be freely downloaded.

3.4 Synthesis and discussion over the literature review

The literature review of this thesis focused on customer value and decision making, since those two areas were seen as important in generating business model according to Business Model Canvas frame work also presented in the literature review. The customer value section supports the value propositions section in the business model canvas. The customer value literature review also benefits the revenue streams and cost structure sections, as the pricing and supplier costs were also discussed in the customer value section.

It can be seen, that the customer value section also remotely benefits the remaining section of the business model canvas, namely, customer relationships, channels, customer segments, key activities, key resources, and key partners. This is due to the reason that improved knowledge of what the customers value might increase the ability to, for example, select the correct customer segments or the supply channels.

The decision-making section was selected to the literature review since the customer decision-making process simulation was experimented in this thesis in order to gain more refined understanding of what the customers might value as a whole, when different investment alternatives were to be compared. The assumption was, that the simulation might reveal some factors that might not otherwise be recognized by the supplier, when generating their business model for the selected market area.

4. TECHNOLOGY CONCEPTS

This chapter covers in brief some different concepts for waste management possibilities in Oman and in general. The level of technical details is not enforced, rather the different concepts are presented in a generic and descriptive manner. Some environmental and economic aspects are also discussed relating each concept.

4.1 Landfilling

For the purpose of presenting the current state in Oman, two types of landfilling are identified. These types are dumpsites and sanitary landfills. Though both of these landfill types are the same by the basic principle, some differences still exist.

Both landfilling types are meant to store and dispose the waste, without any extra handling or processing needed. In essence, the waste is laid on ground, in a place where it causes least amount of disturbance for society, and left there. These disturbances can be, for example, air or audiovisual disturbances. Also the leachate can, for example, find its way to ground water and cause it to be spoiled. Landfills can exist to serve heterogeneous waste, for example, municipal waste, or single component wastes, such as power plant bottom ash (O'Leary & Tchobanoglous 2002).

The operating principle of plain dumpsites is illustrated in the previous paragraph. Using dumpsites is extremely cheap, since no processing is required. However, the environmental risks are large due to the reason that the waste is placed directly on ground. Waste can also, over time, cause methane emissions and even fires. In addition, rodents and other animals can spread the waste and diseases in other locations.

Sanitary landfilling is a next generation landfilling concept. Previously, the term sanitary landfills meant landfills which were covered at the end of the workday (O'Leary & Tchobanoglous 2002). However, later the term is extended to cover more sophisticated and engineered landfills (O'Leary & Tchobanoglous 2002). Thus, the landfill is designed and some construction work is required. For example, in be'ah's presentation, landfill is isolated from surrounding ground by multiple different isolating layers (Tarik 2014). The leachate is also collected from the bottom and pumped to treatment. Methane gas is also collected by using collection pipes and methane gas wells. The landfill is also covered by covering soil in order to prevent animals from spreading waste to other locations. The quality of ground water is also monitored closely. Finally, when the landfilling operations on the site end, the landfill can be entirely covered. Constructing sanitary landfills is more expensive and time consuming, than using dumpsites. However, by using this method the environmental impact is reduced. For example, leachate is processed and the entire landfill is isolated from ground by isolating layers. This means that the ground water does not get spoiled by leachate. Also, if spoiling occurs, the established monitoring system of ground water informs the operators about the problem. Thus, corrective actions can be taken. Also, the landfill is covered, so the smell and visual disturbances should be smaller. On the other hand, the waste is still, in essence, left there without processing and no advantage of the waste is gained. The waste also remains in ground for decades after the landfilling and this method does not actually provide means to discard the waste totally. (Tarik 2014)

4.2 Mass incineration

Mass incineration is a technology concept, where the waste, that otherwise would be landfilled, is incinerate, as is. This means that the waste is not pre-treated before incineration, rather it is fed to the boiler in the same state as it would be dumped on landfill. The waste acts as a fuel in the boiler and thus, the thermal energy contained in the waste is released as heat. This heat can be then captured in the boiler and thus steam can be produced (Brunner 2002, p. 13.73). This hot steam can then be utilized in various purposes.

The incineration of waste gets rid of the actual waste, which is not the case in landfilling. On the other hand, the products of the incineration are bottom ash, fly ash and flue gas in addition to captured heat. The total dry mass of the residues from the incineration typically are around 25 mass percent of the total mass of the fuel fed to the boiler (Hasselriis 2002, p. 13.85). This means, that the ash handling needs to be established. The inert materials that do not burn, for example, metals and minerals, can be captured and recycled from the bottom ash. However, as the incinerated waste is usually very heterogeneous and does not always incinerate completely, the bottom ash is usually quite hazardous and needs to be treated and disposed properly. For this, usually some kind of landfilling method is utilized (Hasselriis 2002, p. 13.95). Other methods could be, for example, use of ash for construction (Hasselriis 2002, p. 13.104).

As the waste is fed to the boiler intact, it consists of different sized particles. Some parts of the waste can be very moist where as some parts may contain high calorific value. This heterogeneous character of the waste causes the incineration process to be designed in extremely robust way. All of the waste might not even have enough time to incinerate properly in the boiler. Also the boiler might suffer from uneven power distribution when some parts of the boiler run hotter than others due to the fluctuation in the fuel quality. These factors cause lower steam values and higher demand for cleaning and processing the bottom ash, separating fly ash from flue gas and treating flue gas. In the end, lower steam values result in lower overall efficiency.

On the other hand, mass incineration of waste is very economical way to get rid of the actual waste. When waste is incinerated and bottom and fly ash is collected, the amount and volume of those is a great deal lower. Thus, the need for landfilling and material handling is reduced significantly. Also, the ash does not smell or attract rodents or other animals or release methane while decaying. Of course, if the incineration is not complete, the ash contains some waste residues and the total character of the bottom ash is something in between ash and waste. However, the method is efficient in lowering the requirements for storing the waste. In addition, some advantage can be taken from the heat captured in the boiler.

The incineration has some environmental effects, for example, CO2 and other flue gas component emissions. The quality of flue gas is quite low and thus flue gas should be treated accordingly. The boiler is also susceptible to the corrosion and staining caused by the impurities of the fuel. This means that the boiler needs to be serviced quite often. On the other hand, the technology is quite well known and thus economical, reliable and predictable.

Some material handling solutions can also be incorporated to enhance the process. For example, some crushing and homogenization of the waste could be done and thus more even feeding and power distribution in the boiler could be achieved. This is due to the fact that the feeding of bulky waste or waste with extreme variation in particle size is very difficult. Thus, even the mass incineration plant operators would prefer some material handling solution to guarantee more even feeding. One practical solution, if crusher is not available, is to try to modify the waste with the grabber in the storage silo. This could be achieved by, for example, grabbing the targeted bulky waste with the grabber, hoisting it high above the ground and then releasing it and letting it drop to the ground and potentially break down due to the impact. This, however, is time consuming and needs to be done separately for each piece of bulky waste and the results are uncertain.

4.3 Separation and recycling or sorting in origin of waste

In order to make waste processing more efficient, the waste can be sorted already in the origin of the waste. This basically means, that the waste producers, for example, consumers or companies, segregate different types of waste into different waste collection containers. For example, in Finland paper, carton, bio waste, and mixed waste are usually collected separately and these containers are usually provided by, for example, housing associations as a default for the residents. In addition, metals and different types of glass can be collected in separate containers. In some cases there is also containers for energy waste and hazardous waste.

Segregation and sorting of the waste in the origin reduces the need to process the waste, since the different collected fractions are already quite clean. For example, collected metals can be melted and collected plastics either reused or incinerated. Segregation reduces the amount of produced mixed waste, which contains many different types of waste and thus, is heterogeneous and requires robust processing to be utilized, recycled, or incinerated properly. For example, in *Waste characterization and quantification – Final munic-*

ipal waste survey in Oman the equivalent for mixed waste, the municipal waste, was further segregated into 17 categories (be'ah 2013). The information about these categories and their masses are presented in table 6 later in the chapter 5.2.2. From these figures, it can be seen that the amount of paper, carton or cardboard and plastics are quite high in the municipal waste in Oman, even though the amounts differ quite significantly depending on the region. This differentiation was noted in the survey and based on the different degree of urbanization and local factors (be'ah 2013).

4.4 SRF – Solid Recovered Fuel

Solid Recovered Fuel (SRF) is a type of fuel that is achieved through refining non-hazardous waste, mainly Municipal Solid Waste (MSW). SRF is a standardized fuel meaning that its characteristics must be specified according to the standard for it to be called SRF (Solid recovered fuels. Specifications and classes 2012). As a fuel SRF can be used in, for example, cement kilns, combined heat and power plants and normal power plants to produce electricity. (European Recovered Fuel Organisation 2015)

SRF has usually quite high caloric value, allowing high steam parameters and easy combustion even without auxiliary fuels or co-combustion. High steam parameters and possibility to use SRF also in cement kilns and CHP plants make the use of SRF more sustainable and energy efficient method than simple mass incineration of waste in, for example, grate fired boilers. SRF can also be used as a substitute for fossil fuels such as coal, thus lowering the environmental impact of the plant.

Typically SRF looks like lightweight fluff which has small particle size. This is because during manufacturing process the waste is crushed and metals, both magnetic and non-magnetic, and inert components such as rocks, dirt, bricks and glass are separated. Sometimes organic fractions can also be separated from the SRF. The resulting SRF contains mainly well combustible components such as wood, paper, plastic and biomaterial etc. In Figure 7 there is typical SRF.

Figure 7. *Finished SRF ready to be incinerated (BMH 2014)*

To allow the name SRF the producer has to comply with EN 15359. This includes the specification and classification of SRF according to EN 15359, using defined measuring methods and forms in reporting. The classification of the SRF is done based on the thorough specification of SRF characteristics. The main reason for classification is to give a quick and easy way to compare different SRF with each other based on their market value, corrosiveness during incineration and environmental impact. However, even though the use of the term SRF requires all this, the term SRF isn't certified. This means that the SRF doesn't yet have a product status and it is still considered to be waste that is however intended to be incinerated in combustion or co-combustion process. The possible future certification could allow distinguishing between high caloric value SRF and lower grade fuels by limit values and possibly allow SRF a product status. (Solid recovered fuels. Specifications and classes 2012)

4.4.1 SRF Standard

In the standard EN 15359 it is stated that the producer has to specify the origin of the waste, particle form and size, moisture content, ash content, net caloric value, chlorine content and different heavy metal (Cl, Sb, As, Cd, Cr, Co, Pb, Mn, Hg, Ni, Ti, and V) contents, both separate and as summed together. This information is filled in a given normative template. On top of this producer can give auxiliary information on such form including for example bulk density, composition, ash melting behavior etc. (Solid recovered fuels. Specifications and classes 2012)

The SRF is divided in five different classes according to its Net calorific value (NCV), Chlorine content (Cl), and Mercury content (Hg). The NCV represents the market value of the SRF, Cl represents the corrosive effect of the SRF during the incineration, and the Hg represents the environmental impact of the SRF. In Table 3 there is indicated the limit values for NCV, Cl and Hg. There is also given an example of how the classification is actually done and the SRF given three part “Class code”. (Solid recovered fuels. Specifications and classes 2012)

Table 3. *SRF Classification and Class code (adapted from European Recovered Fuel Organisa-tion 2015)*

Classification characteristics	Statistical measure	Unit	Classes				
			1	2	3	4	5
Net calorific value (NCV)	Mean	MJ/kg (ar)	≥ 25	≥ 20	≥ 15	≥ 10	≥ 3

Classification characteristics	Statistical measure	Unit	Classes				
			1	2	3	4	5
Chlorine (Cl)	Mean	% (d)	≤ 0,2	≤ 0,6	≤ 1,0	≤ 1,5	≤ 3

Classification characteristics	Statistical measure	Unit	Classes				
			1	2	3	4	5
Mercury (Hg)	Median	mg/MJ (ar)	≤ 0,02	≤ 0,03	≤ 0,08	≤ 0,15	≤ 0,50
	80th percentile	mg/MJ (ar)	≤ 0,04	≤ 0,06	≤ 0,16	≤ 0,30	≤ 1,00

Example of classification
SRF having a mean net calorific value of 19 MJ/kg (ar), a mean chlorine content of 0,5% (d) and a median mercury content of 0,016 mg/MJ (ar) with a 80th percentile value of 0,05 mg/MJ (ar) is designated as: "Class code NCV 3; Cl 2; Hg 2".

Complying with the EN 15359 standard does not, however, mean achieving end-of-waste status. This means that SRF doesn’t automatically get a product status and is thus still considered as waste even though it is destined to be incinerated as a fuel to produce energy. The standard does not also take any account in limit values of the incineration and whether or not the SRF should be incinerated with or without auxiliary fuels. This must always be done case by case by a professional. However the work done to specify the SRF is an efficient tool for the professional in deciding about how the incineration is to be performed. (European Recovered Fuel Organisation 2015)

4.4.2 SRF Production

In a typical production process the SRF is achieved by refining non-hazardous waste, typically MSW. The waste is first crushed, after which some separation is done from the material flow of the crushed waste. Separation is achieved through magnets, sieves, eddy current and air classifiers. In Figure 8 there is a simplified illustration of an example of a typical SRF production line.

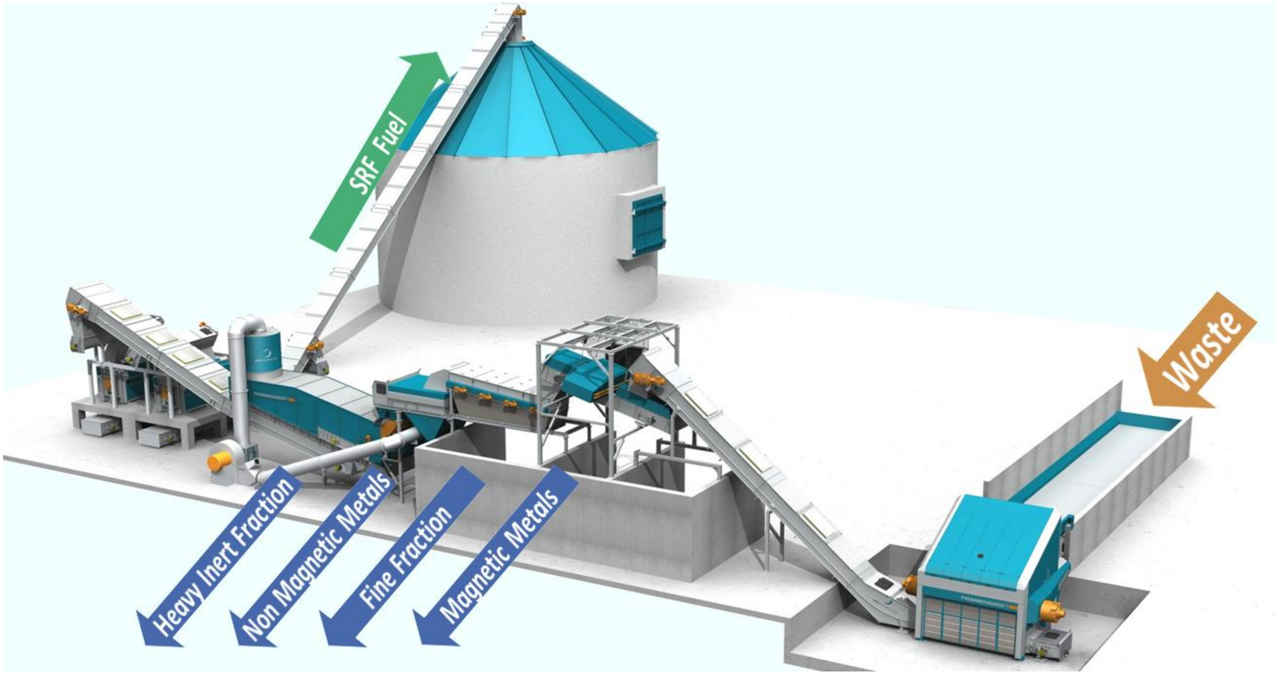

Figure 8. *Example of a typical SRF production line (BMH 2014)*

Magnets are used to separate the magnetic or ferrous metals from the other material flow. Different types of sieves are used to select different particle sizes from material flow. This allows for example separation of fine fraction from the material flow. Eddy current is used to separate non-magnetic metals since by definition they are not separated by magnet. Inert heavy fractions such as glass, dirt, rocks and bricks etc. are separated in air classifier.

Basically any form of combustible waste may function as an input for SRF production process. These include domestic and industrial waste, scrap tires, textiles, plastics, paper etc. In Figure 9 there is illustrated different potential waste sources.

Figure 9. *Different waste sources for SRF production (BMH 2014)*

The net calorific value of the SRF depends on the quality of the input waste. For example the high plastic content increases the net calorific value, since the plastic itself has a high calorific value. On the other hand, plastic doesn't absorb moisture, which lowers the net calorific value. Vice versa, high organic content might affect lowering the net calorific value since organic fraction contains a lot of moisture.

4.4.3 Co-fuel in cement industry

Incinerating waste as a co-fuel in cement kilns offers an interesting alternative for waste management. In this technology the ash produced while incinerating waste is captured in the cement manufacturing process. Formed ash is mixed in the cement in the process, increasing its volume. Produced cement functions as a final disposal method for waste. On the other hand, it increases the yield of cement per valuable raw materials. On the other hand, disposing the waste incineration residues into a cement offers a safe way to get rid of the waste problem. In this form, the potentially hazardous components contained in waste are in insoluble and fixed form and thus those components will not cause any further environmental problems. It also replaces some of the otherwise used fossil fuels. Thus, using waste as a co-fuel offers many advantages over using only primary raw materials and some fossil fuel in production process, both from environmental and economical points of view.

However, the waste must be of a high quality and very homogeneous to ensure even cement quality. The waste must be also shredded into a very small particle size to enable fine ash particle size and low amount of incombustibles ending up in the finished cement. Ensuring these high requirements some investments into special processing equipment of the waste need to be done. On the other hand, the resulting advantages of using waste may, in some cases, overcome the total cost of investments. In some cases, the operator may also receive gate fees as extra income per received waste ton and even some extra income from selling the possible recyclables separated from waste while preparing the waste for cement kiln. For example, SRF can be further refined into fuel that is combustible also in cement kilns by shredding it to smaller particle size.

4.4.4 Use in power plants

Using SRF has many important advantages over mass incineration of waste, for example, in grate fired boiler. First of all, SRF production process enables recycling important fractions of the waste, most importantly different metallic fractions. On the other hand if these are not removed from the waste material flow before incineration they might melt in the boiler or cause some other problems by, for example, blocking moving grate parts. These problems cause lower operating hours and increased maintenance costs.

Due to small particle size and high calorific value SRF can be incinerated in fluidized bed. This has amongst other things, for example, following benefits. Firstly, utilizing fluidized bed technology allows higher incineration efficiency due to additional mixing during combustion. Secondly, higher stability due to additional heat capacity from the fluidized bed material. Also capability to incinerate fuels with very high moisture content. Thirdly, higher steam parameters and thus higher overall efficiency, because the super heater pipes can be submerged in bed material that has already been purified in cyclone from the corrosive ash components. Some other benefits are listed in bullet points below.

- Lower incineration temperatures and possibility to combustion air phasing cause lower NO_x and CO emissions
- Increased fuel flexibility enables the use of different fuels in case of need of for example auxiliary fuels
- Smaller boiler due to increased heat transfer rate caused by the fluidized bed material
- Lower incineration temperatures help minimize the corrosive reactions in the boiler increasing operating hours
- Since SRF is standardized fuel and the producer is required to specify the SRF very carefully, the composition of the SRF is always known in a very detailed level. This helps plant operator in, for example, estimating the maintenance need.

Using SRF as fuel also lowers the fossil CO_2 emissions. This lowers the amount of potential CO_2 emission fees. Integrating an SRF production line into the rest of the power plant allows the operator also to receive gate fees from the waste they receive. Use of SRF also solves local waste problems. Overall the use of SRF promotes recycling, increases profits by unlocking new channels of income (gate fees, selling recycled materials) and has several environmental benefits over mass incineration of waste.

4.4.5 Waste to water

Electricity and thermal energy produced in the power plants while incinerating SRF can further be used to produce fresh drinking water from sea water by utilizing some desalination technology. This text briefly introduces two desalination technologies to give reference of the concept. These technologies are vacuum distillation and reverse osmosis. However, other technologies also exist.

Vacuum distillation is a form of distillation, where the water is distilled in sub atmospheric pressure. The distillation works by boiling the water, conveying the steam into another container and condensing it there again into liquid by, for example, cooling it down below the dew point. The boiling point of water is 100°C in normal atmospheric pressure. However, by lowering the ambient pressure, the boiling point also decreases. This is presented in Figure 10.

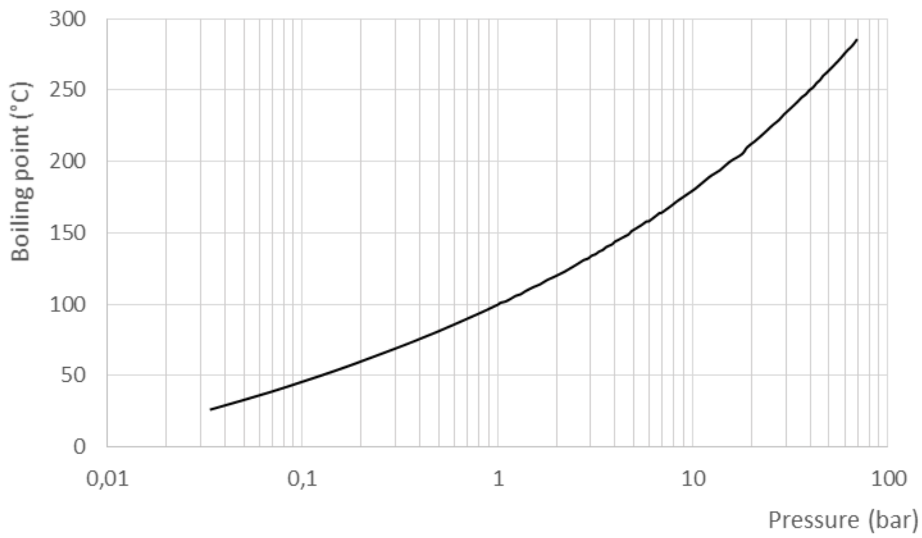

Figure 10. *Relation of boiling point and pressure for water (adapted from Engineering ToolBox 2015)*

Lowering the boiling point by lowering the ambient pressure allows the use of cooler boiling. Thus, the operator can utilize, for example, heat streams that would otherwise be wasted. Such waste heat streams could be, for example, hot air from air conditioner or power plant condensate water. While the required temperature for boiling point decreases, the required energy for boiling a mass unit of water remains constant. Thus, the method remains quite energy intensive, even though lower value heat streams may be utilized.

On the other hand, utilizing such waste-heat streams increases the overall efficiency of the process.

Reverse osmosis relies on semipermeable membranes, that passes water molecules but does not let salt ions to pass through it. Osmosis is a natural process, which evens out differences in concentrations. This is achieved by conveying water from lower concentration to higher, thus diluting the higher concentration. However, in reverse osmosis, high pressure is applied on seawater on the other side of the membrane and low pressure on the freshwater side of the membrane. When this pressure difference exceeds the osmotic pressure caused by the gradient in the salt concentration over the membrane, the pressure pushes the water molecules from the sea water side on the fresh water side and the salt ions are left on the sea water side. Thus, fresh drinking water is created from sea water. The method is quite energy consuming, since the pressure gradient over the membrane must constantly exceed the osmotic pressure caused by the ion concentration gradient. However, the method is quite feasible and generally adopted.

4.4.6 District cooling

Using the energy produced in power plants for refrigeration is also one interesting technological option. The electricity or even the direct rotary movement of the turbine could be harnessed to rotate refrigerator compressors. Thus, a large scale refrigeration station could be powered. This refrigeration capacity could be delivered forwards to, for example, consumers, office buildings, and shopping centers by the same method that district heat is delivered in northern countries. In Finland there is also already some commercial applications of district cooling at least in Helsinki and Tampere (Helen Oy 2015; Tampereen Sähkölaitos Oy 2015).

In district cooling, the network is constructed like in district heating. The heating or cooling medium flows from the heating or cooling site to the customers via insulated pipes and circulates back to the site. The medium’s potential to deliver heating or cooling is regained at the station and it releases its heating capacity or cools by absorbing heat at the customer’s heat exchanger. The distances from the heating or cooling site to the customers cannot be too long, but the method is capable to function in urban distances. The increase in customer density also increases the method’s efficiency, while less thermal potential is lost in transferring the medium from site to the customers and back.

Using steam and compressor process in refrigeration is quite well known and conventional technology. For this reason, this thesis focuses only on that technology on refrigeration technologies, even though other technologies exist, such as Peltier elements or magnetic refrigeration. The compressor process method is used, for example, in cars, kitchen refrigerators, and industrial scale air conditioning. The reverse process is utilized, on the other hand, in heat pumps, to develop heat during colder weathers. Thus, this method can also be constructed to be reversed and to deliver either cooling or heating depending on demand, with reasonable efficiency.

4.5 Others

This chapter discusses some other technology concepts regarding waste treatment. These methods may not necessarily be oriented into disposing the waste, but to refining it or being a part of, for example, SRF production process.

Three separate technologies are discussed. These are bio drying, gasification, and composting. First chapter presents drying technologies by utilizing the heat generated by bacteria in the waste itself. Second chapter, gasification, is further divided in bio- and thermal gasification and both of these are presented and discussed. Lastly, composting is discussed as a method to treat and dispose bio waste.

4.5.1 Bio drying

Drying the fuel increases its calorific value, since there is less moisture to heat up to boiling point and then evaporate and further superheat the steam. This means, that one mass unit of the fuel produces more energy when combusted and thus increases the ambient temperature more. This is because there is less amount of water and thus more fuel in the mass unit. On the other hand, since this moisture is not a component advancing the incineration, its heating and evaporation process only captures energy from the combustion of the actual fuel. This is not necessarily devastating for the boiler operation, since the same energy is released in combustion, only part of it is stored as the thermal energy of steam in the flue gas and can still be retrieved in, for example, heat transfer pipes. On the other hand, this lowers the temperature of the flue gas, causing lower efficiency and heat transfer coefficient in the boiler.

Since the waste has usually quite high moisture content, drying it may be beneficial in order to capture the maximum amount of energy from the waste in combustion process. On the other hand, drying itself requires also energy and time. The waste needs to be arranged properly for the drying and the conveying of the humid air out and dry air in has also to be arranged to enable the potential for drying. After the drying, the waste needs to be collected to make room for new wet waste. The drying also takes some time, depending on the drying conditions. For example, the drying time can be reduced by providing good drying conditions. In general, the lower the relative humidity, higher the temperature and greater the flow of the drying air, the faster the drying is.

One other method for drying is bio drying. In this method, the heat produced by the bacteria as a side product of their metabolism, is used to heat the air and waste and thus to evaporate more moisture off of the waste. The waste is usually covered by membrane cover to let the air and steam pass, but keep the rodents and other animals out and to make the system more sanitary. The organic material in the waste feeds the bacteria, enabling them to reproduce and to provide heat for the process. Air is blown into the waste so that the continuous airflow inside the waste would cause the relative humidity to remain low inside the waste and thus promoting the drying. Some of the organic content of the waste is lost in this operation, as the bacteria consume it and transfer it to carbon dioxide and heat. On the other hand, the drying is efficient, and the air does not need to be heated separately. The process can be also sustained in colder weathers. (Convaero 2015)

4.5.2 Bio- and thermal gasification

Gasification converts solid organic material into flammable process gas. This process gas can further be refined by cleaning and, if necessary, by liquefying, into high quality gas or liquid fuels. In this chapter, two gasification methods are presented. These are bio gasification and thermal gasification.

In bio gasification, biodegradable material is transformed by bacteria into methane, carbon dioxide, and some impurities through various phases. This process happens in bioreactors in anaerobic state. For this reason, bio gasification is also referred to as anaerobic digestion. Other outputs for this process are solid digestate, which can be used as, for example, fertilizer, and waste water which requires further processing and purifying.

Thermal gasification converts material that contains elementary coal, into process gas, called syngas. The thermal gasification resembles combustion, since the process happens in relatively high temperature and produces heat, but it happens in sub stoichiometric state. This means, that there is less oxygen present in the reaction as would be needed for the material to combust in an ideal combustion by the chemical reaction equation. Thus, the combustion lacks oxygen and the combustion is imperfect. The syngas is then mostly carbon monoxide (CO) and hydrogen (H_2), instead of carbon dioxide (CO_2) and water (H_2O). The syngas is then also flammable, since it can react with oxygen (O_2). It can be then purified from other impurities and liquefied. High quality liquid fuels can be produced from the syngas by further refining it. One example of this is producing liquid hydrocarbons in a process called Fischer–Tropsch process. (Spath & Dayton 2003)

One advantage of thermal gasification is that the organic compounds containing coal are quite efficiently gasified, whereas the inert components remain in the bottom ash and can then be recycled properly. After purifying the process gas it can be incinerated in quite high temperatures, enabling high efficiencies for the heat transfer and steam processes. On the other hand, the process where the extremely heterogeneous waste is present, happens in relatively low temperature compared to, for example, direct combustion of waste. The lower processing temperature of waste reduces the corrosive effects to the gasifier by the hazardous chemical components in the waste. On the other hand, investing in gasification process is an additional cost. Thus, the benefits gained must outweigh the additional costs. (Spath & Dayton 2003)

4.5.3 Composting

Composting offers a quick and easy way to process easily degradable bio waste. This method works well on materials such as animal and plant tissue, but does not perform very effectively on materials such as wood, polymers or leather and does not work at all on materials such as glass, ceramics or metals (Diaz et al. 2002, p. 12.1). The main outputs of composting are carbon dioxide, water, and compost, which in essence is extremely fertile soil (Diaz et al. 2002, p. 12.1).

Composting is, like bio gasification, executed by microorganisms, such as bacteria, but also, for example, fungi, worms and larvae (Diaz et al. 2002, p. 12.3). On the other hand, while bio gasification is executed in absence of oxygen and thus is an anaerobic process, composting is aerobic process and consumes oxygen. In essence, carbon contained in compost is transformed into carbon dioxide by reactions with oxygen and the hydrogen of carbohydrates are transformed into water, also by reactions with oxygen. This is exothermic reaction and thus the composting produces also heat as the bio heat of the living organisms in the compost.

Due to the production of heat compost evaporates water quite rapidly when functioning correctly. For this reason, the compost might need to be irrigated, as a sufficient level of moisture is required for the microbial activity and thus for the composting to occur (Diaz et al. 2002, p. 12.10). The compost needs also sufficient aeration, since the process is aerobic due to the normal metabolism of the microorganisms. Sufficient aeration can be provided by, for example, turning the compost every now and then.

5. WASTE COLLECTION

In this chapter the selected collection solution for waste in Oman is presented and discussed. The collection solution was selected according to quite general variables, since the focus of this thesis is not to provide optimal collection solution but to give insight in what could be done with the collected waste and thus, give input for the waste handling supplier's business model generation. For additional reading and literature from optimal collection and vehicle route optimization one can look for, for example, Kim et al., Taniguchi et al., Tatsiopoulos & Tolis, and Nuortio et al. (Kim et al. 2006; Taniguchi et al. 1999; Tatsiopoulos & Tolis 2003; Nuortio et al. 2006). In summary, there exists software tools for optimizing vehicle routing and collection of various materials or other supply chain components against various problem variables, such as distance, time, costs and environmental effects of the supply chain.

5.1 Background

The guiding material for the location and amount of different waste sources in Oman in this thesis is *Waste characterization and quantification – Final municipal waste survey*, which was ordered by be'ah and has been published in march 2013 (be'ah 2013). In this research, be'ah surveyed national dumpsites of different sizes in two seasons in 2012 to assess the amount and composition of the waste produced in Oman in different locations (be'ah 2013). The dumpsites were divided into four categories, large, medium, small and very small dumpsites. The information about these dumpsites is presented in Table 4 below.

Table 4. *Dumpsites in the Sultanate of Oman and number to be surveyed according to the statistical approach (be'ah 2013)*

Dumpsite group	No of inhabitants delivering waste to the dumpsites	Number of dumpsites	Total no. of inhabitants delivering waste to all dumpsites in this group (2010 figures)	Percentage of inhabitants in the Sultanate of Oman	Number of dumpsites to be sur-veyed
Large	>100 000	4	1 136 301	41%	4
Medium	50 000-100 000	11	731 518	26%	10
Small	10 000-50 000	26	638 349	23%	21
Very small	<10 000	325	267 312	10%	0
Total		366	2 773 479	100%	35

The industrial waste was surveyed separately and thus isn't included in *Waste characterization and quantification – Final municipal waste survey*. However, a brief summary of the non-hazardous industrial waste is included in the report. Thus, the report gives quite comprehensive and inclusive description of all the non-hazardous waste produced in Oman annually and the more accurate amount locally. The survey provides also a forecast for years 2017, 2022, and 2032. Of these figures the 2012 figures were used in this text due to the assumed static 5% annual growth rate for the future figures and the 2012 figures representing the actual measured data. The waste composition and amounts for current situation and given forecast is presented in Table 5 below. (be'ah 2013)

Table 5. *Present situation (2012) and 5, 10, and 20 years period forecast of waste generation in Oman (ton/year) (be'ah 2013)*

Waste type	**2012**	**2017**	**2022**	**2032**
Municipal waste	880 000	1 034 000	1 216 000	1 679 000
Garden and park waste	112 000	132 000	155 000	214 000
Slaughter waste	1 400	1 600	1 9000	2 700
Industrial waste	79 000	93 000	109 000	151 000
Total	1 073 000	1 261 000	1 482 000	2 047 000
Waste tires	31 000	46 000	58 000*	No data

**2020 figure*

The survey was concluded at the statistically selected dumpsites by trained teams. They registered all the incoming trucks by, for example but not limited to, truck capacity, filling volume, waste type, and collection district. In addition, the trucks were weighted when entering and leaving the dumpsite. Some trucks were also selected by random for sorting. This meant that a sample of preferably 91-136kg of waste was collected from the vehicle and sorted by hand. This was done to survey the local waste composition in addition to the general waste amount. (be'ah 2013)

5.2 Variables affecting the collection

As the scope of this thesis was not to provide optimal collection concept for the waste in Oman, some assumptions and simplifications were made in order to provide a general collection concept to work from. The waste generation locations were simplified to be specific points on map. These points were the map points of each wilayat (i.e., province), as the incoming waste trucks were registered also by the wilayat or province where the truck was coming from. This method gave more precise deviation versus if the locations would have been only the dumpsites. However, the method still contains some inaccuracy, since the waste surely does not generate in the middle of the map point of each wilayat. However, the method gives a reasonable enough waste location deviation in a sufficient accuracy.

Some wilayats were not able to directly be placed on the map. This was due to, for example, spelling errors or different names for a same wilayat or other reasons that Google maps did not find the searched wilayat. A comprehensive listing of all wilayats and collection stations, possible interpretations or assumptions, the associated coordinates of the wilayat waste location and decided collection locations are presented in appendix 1.

5.2.1 Yield per location

In order to simplify the collection problem, it was decided that the collection should be organized in a way that the driving time from the location where waste was originated to the collection site should not exceed two hours. It appeared also, that this rule complied well with radius of 100km. Thus, the collection was organized in an approximately 100km radius collection clusters. A complete map of Oman and the decided collection clusters are presented later in this text in Figure 11. The only connection that exceeds the driving time of 2 hours is from As Sunainah collection point to Sohar-Yanqul collection cluster center. This driving time is, according to Google maps, 2 hours and 10 minutes. Because the driving time exceeds the 2 hours mark only by 10 minutes, and the locations of the collection clusters aren't exactly fixed but rather approximate, as discussed later in the text, it was decided to include also As Sunainah map point to Sohar-Yanqul collection cluster.

In the map in Figure 11, the collection centers are marked as stars. Each star is color coded and the other color coded markers represents the collection locations from where the waste is collected to a certain collection center. The grey ones are outside the collection radius and are not collected to the collection centers. From the Table 6 below can be seen, that this collection method captures roughly 98% of the year 2012 recorded waste amount in Oman. Thus it was decided that extending the organized collection to the most remote areas for the sake of the remaining under 2% would not be cost effective. A local method of waste disposal is thus recommended for these remote areas.

Table 6. *Amount of waste per collection center (tons/year) (2012 figures) (be'ah 2013)*

Collection site name	Park & Garden Waste	Municipal Waste	Slaughter	Industrial waste	Total	% - of tot
Salalah	19 132	174 151	0	2 183	195 469	18,22 %
Al Kamil	11 866	64 651	40	1 055	77 612	7,23 %
Muscat	50 150	390 484	603	58 648	499 888	46,60 %
Sohar-Yanqul	26 366	186 923	663	16 212	230 165	21,46 %
Adam	2 756	45 397	74	774	49 001	4,57 %
Total	**110 270**	**861 606**	**1 380**	**78 872**	**1 052 135**	**98,08 %**

From Table 6 it can also be seen, that Salalah, Muscat and Sohar-Yanqul areas are the greatest in terms of waste production, while Adam and Al Kamil are, though remarkable, as a whole smaller than the three others. Thus it would be reasonable to first concentrate on the three greatest areas.

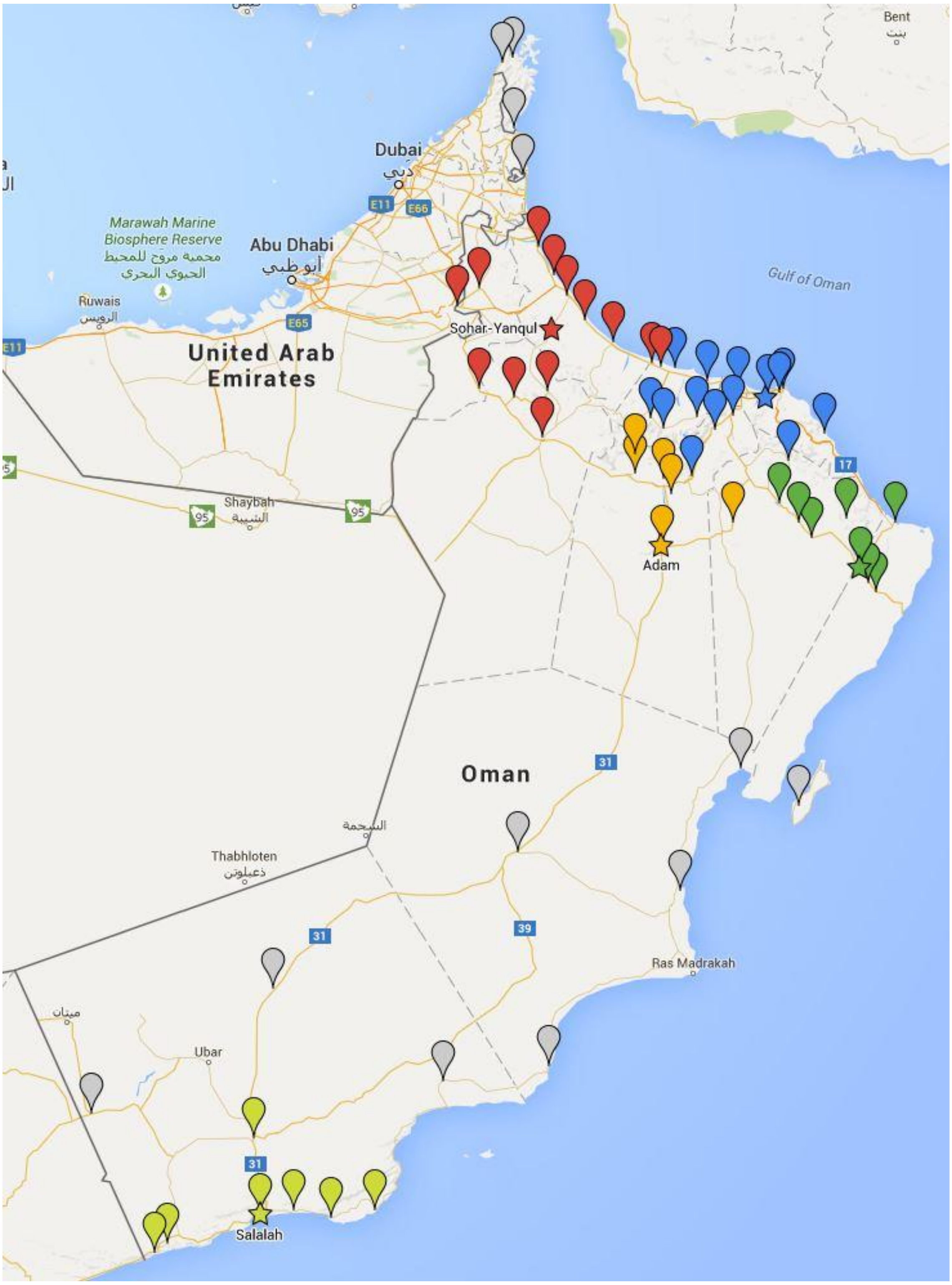

Figure 11. *Map of collection centers and clusters*

The four most northern grey map markers belong to the Musandam region. The three northernmost, Bukha, Khasab and Dibba are located so near to each other, that the 2h driving time is not exceeded. The fourth, Mudha, is located not only farther away from the previous three, but on isolated land area, surrounded by United Arab Emirates, as well. Thus, connecting it to the collection center is impossible. However, the three northernmost locations could be considered to connect as one extra collection center. However, the yield of this collection center would be very small and consist only under 1% of all the waste created in Oman. The amounts are presented in Table 7 below.

Table 7. *Possible collection center of Musandam: Bukha, Khasab and Dibba (tons/year) (2012 figures) (be'ah 2013)*

Collection site name	Park & Garden Waste	Municipal Waste	Slaughter	Industrial waste	Total	% of tot
Musandam	968	7116	0	55	8139	0,76 %

For the reason that the Musandam collection area yield would remain very low, it was discarded from this thesis. For future purposes it is, however, important to know that this area could contain some potential for collective waste collection.

There is no Google street view available from Oman streets or roads and thus, it is difficult to visually asses the condition of some of the more rural road connections used between selected maps points and collection clusters without being able to actually travel on site. However, according to the visual assessment of the main roads and the more rural roads that were seen during the trip to Oman, the roads were in sufficient condition. For this reason, the driving time is taken as granted by Google maps driving directions functionality and no further assessment on that matter is done.

As previously mentioned, the placing of the collection centers on the map is approximate and not fixed. The purpose of placing them was to get some reference on choosing what waste generation locations or wilayats would be included in which collection center. Thus, the collection centers can be considered to only represent roughly the area where they could be located. For example, collection centers could be actually located in the same property than the current dumpsites, which are quite near the marked collection center locations. Because of the inaccuracy, it was also decided that the As Sunainah map point would be accepted to the Sohar-Yanqul collection cluster. For reference, a map of the Oman dumpsites is presented below as it was presented in *Waste characterization and quantification – Final municipal waste survey. (be'ah 2013).*

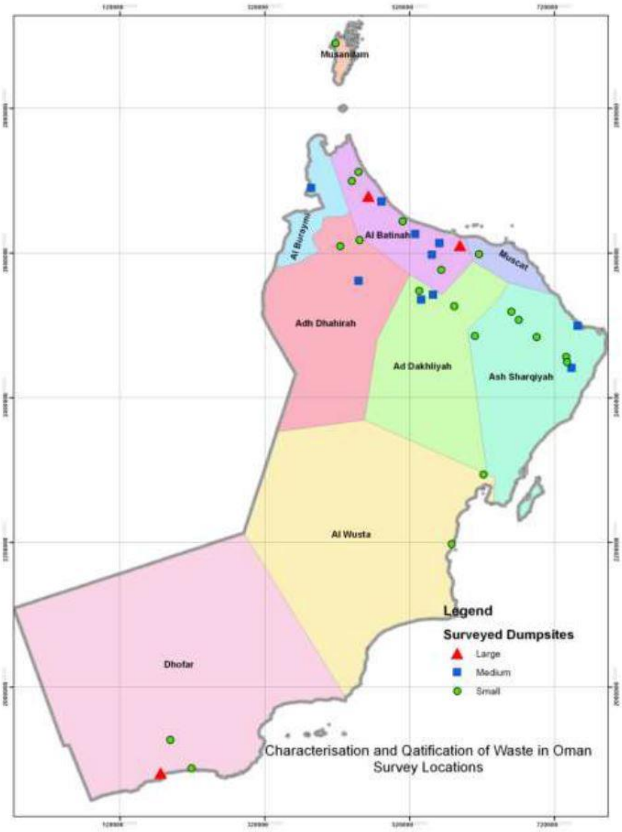

Figure 12. *Oman dumpsites that were included in the survey (be'ah 2013)*

As can be seen from Figure 12, there is always a dumpsite, either large or medium sized, quite near the area where the collection center was marked in Figure 11. Thus, one proposal for the location of the collection centers could be next to the existing dumpsites, if feasible.

5.2.2 Waste quality per location

The quality and parameters of waste was analyzed also according to the information presented in *Waste characterization and quantification – Final municipal waste survey.* The data was processed in Microsoft Excel and the composition of municipal waste was calculated per collection cluster. This was important, since the collection clusters cross with governorate borders and the municipal waste composition was only given in a governorate level. The wilayat level composition of different major waste streams in tons per year is presented in appendix 2. The municipal waste composition by wilayat is then presented more accurately in appendix 3. In appendix 4 the overall waste per created collection cluster is presented. The calculated waste composition for collection clusters is presented in Table 8 below.

Table 8. *Waste composition per collection cluster (be'ah 2013)*

	Salalah	**Al Kamil**	**Muscat**	**Sohar-Yanqul**	**Adam**	**Total**
Park & Garden Waste	19 132	11 866	50 150	26 366	2 756	110 270
Municipal Waste	174 151	64 651	390 484	186 923	45 397	861 606
Food waste	*51 375*	*18 167*	*97 298*	*47 583*	*14 398*	
Park & garden waste	*2 612*	*1 130*	*9 965*	*4 273*	*518*	
Other bio waste	*174*	*555*	*26 672*	*28*	*246*	
Paper	*4 180*	*1 665*	*29 406*	*7 605*	*1 276*	
Cardboard	*11 668*	*6 864*	*41 573*	*19 507*	*4 725*	
Soft plastic	*24 381*	*5 035*	*47 769*	*18 981*	*3 979*	
Other plastic	*20 376*	*6 309*	*31 254*	*19 666*	*4 171*	
Ferrous metal	*2 090*	*760*	*8 386*	*2 778*	*770*	
Non-ferrous metal	*174*	*21*	*133*	*105*	*86*	
Glass	*5 573*	*3 062*	*14 943*	*8 621*	*1 705*	
Wood waste	*4 528*	*1 932*	*6 608*	*6 484*	*1 062*	
Textile	*10 275*	*4 254*	*23 298*	*11 472*	*2 940*	
Bulky waste	*0*	*0*	*152*	*1 657*	*120*	
Construction and demolition waste	*0*	*164*	*123*	*2*	*42*	
Hazardous waste	*0*	*0*	*1 590*	*166*	*40*	
WEEE	*2 612*	*164*	*794*	*1 103*	*120*	
Other waste	*34 482*	*11 611*	*50 342*	*39 304*	*9 237*	
Slaughter	0	40	603	663	74	1 380
Industrial waste	2 183	1 055	58 648	16 212	774	78 872
Total	**195 469**	**77 612**	**499 888**	**230 165**	**49 001**	**1 052 135**

In Table 8 the municipal waste is presented first as a total and then divided into its components. This is to help decide what could be later done with the municipal waste, as it is the greatest single component in the collected waste stream. The graphical representation of the waste composition is presented below in Figure 13.

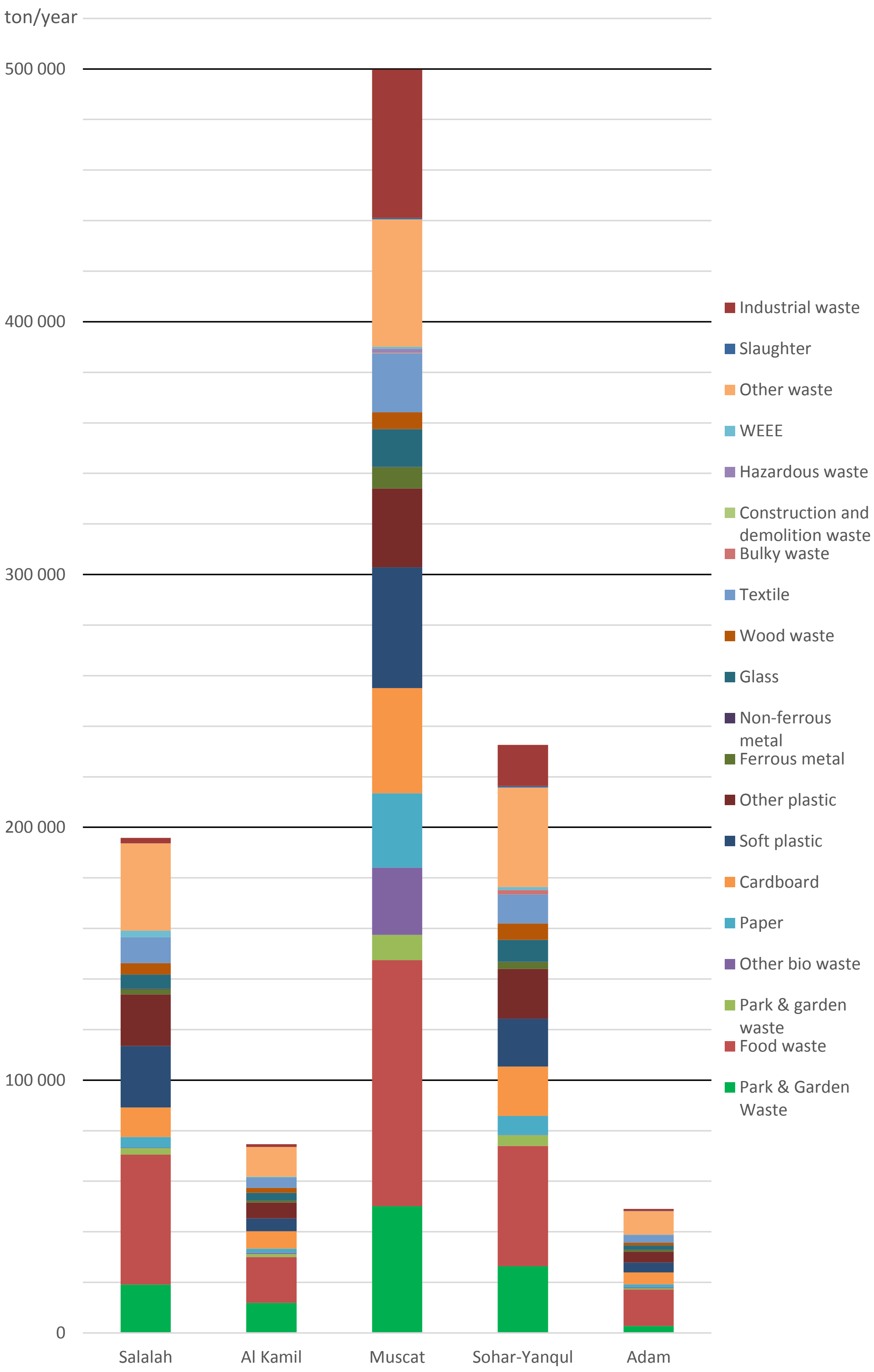

Figure 13. *Waste components and amounts by collection cluster (be'ah 2013)*

The difference in total waste amount is quite clear from Figure 13. Also the composition of waste varies between collection clusters. For example, from Figure 13 it can be observed that in Muscat cluster the amount of plastics, soft and other, is quite high compared to, for example, Al Kamil cluster. The reason to this might be that there is no plastic bottle recycling system in place in Oman (be'ah 2013). For this reason the municipal waste contains high amounts of plastics compared to, for example, Finnish municipal waste. It is also notable, that there is also a separate fraction of park & garden waste contained in municipal waste category. This is due to the reason, that the waste trucks were categorized in classes: park & garden waste, municipal waste, slaughter waste and industrial waste (be'ah 2013). However, the nature of the municipal waste is very heterogeneous. Thus, when it separately sorted, it might contain also some park & garden waste. The two fractions of park & garden waste are presented separately to get the picture of the amount of park & garden waste ending up in municipal waste. The first listed is in all cases also the larger fraction of park & garden waste and that is the separately collected waste stream. It is marked in bright green to the Figure 13, while the fraction that is contained in the commonly collected MSW is marked in light green in Figure 13.

6. DECISION-MAKING SIMULATION

In this chapter the selected technology options or alternatives per location are discussed. First the selected decision-making criteria and their weight coefficients are presented. Then, general assumptions regarding the decision-making and how, for example, the profitability calculations were concluded, are discussed. Then each of the five locations, which were defined in previous chapter, are discussed and the relevant options are presented. Finally, the results of the customer decision-making simulations are presented. This result is then utilized in the next chapter in creation of the actual Business Model Canvas for Omani market.

6.1 Selected decision-making simulation criteria and their weight coefficients

The identification of the criteria and their weight coefficients were conducted as an iterative process in order to show the cumulative nature of the knowledge gathered during the thesis project. Three separate iterations were concluded. These three were the initial identification, refined identification after the trip to the Oman and discussing with the local authorities and stakeholders, and finally the final identification executed in a workshop together with supplier company professionals and FMEA consortium representative. The initial identification was concluded only by the author and relevant literature, online material and, for example, PESTEL framework was utilized. This initial identification of the criteria for the decision-making and their weight coefficients are presented in the Table 9.

Table 9. *The initial (1st) decision-making criteria and their weight coefficients, categories and objectives*

Category	Criteria	Weight coefficient (1-5)	Objective (min/max)
Financial	Net present value	3	max
	Payback time	3	min
	IRR (project)	1	max
	Demand for side products	5	max
	Consumption of scarce resources	5	min
	Initial investment	4	min
Ecological	Waste disposal	5	max
	Environmental safety	4	max
	Low emissions	3	max
	Compact	1	max
	Waste hierarchy	2	max
Social	PR-value for be'ah and Oman (National and International)	4	max
	BAT	4	max
	Consumer preference	2	max
Utility	Availability	3	max
	Need for service	3	min
	Complexity	3	min

As can be seen from the Table 9, the selected criteria were divided into four main categories. These categories were selected to represent different aspects and objectives of the decision-making situation and to take into account the different interests of various stakeholders. The selection of criteria utilized and adapted the PESTEL framework, which is developed to assess the effects of external factors to the company (Professional Academy 2015). PESTEL comes from the words Political, Economic, Social, Technological, Environmental, and Legal (Professional Academy 2015). In this criteria selection, the mentioned factors are considered in different depths. Political factors are in synergy with environmental factors, as be’ah is government owned and the improvement in waste management in Oman is political goal and decision. Economic factors are taken into account separately as well as social factors. However, social criteria represents also the political factors, as the BAT is considered to be the internal national goal, as described in more depth later in this text. Technological factors are taken into account in utility criteria and partly also in social criteria. Environmental factors are considered in the ecological criteria and social criteria and. Finally, legal factors were more or less left out from the consideration, as the investments are not seen to be in contradiction with local laws and also the government itself has made the initiative to enhance the waste management.

The economical category received quite low weight coefficient compared to the reality that the decision-making situation was all about different investment alternatives. Generically, this would imply that the financial criteria would receive the highest weight coefficients, as the investments are usually done in the profitability basis. However, be'ah is fully owned by government and it exists to provide a utility service, waste management. Waste management is, then again, a service that has to be provided anyway, and usually it is organized by the society, which is also the case considering be'ah and this decision-making situation. Thus, although still important, the financial criteria do not play such a great role that they would do in a normal business ventures. However, the weight of the criteria has shifted towards more ecological, social, and utilitarian criteria.

It is also important to note, that in general, the ecological, social, and utility criteria are very abstract. Thus, the assessment of the different investment alternatives according to these abstract criteria is not exact. On the other hand, also the financial values of the different investment alternatives contain some inaccuracy. This was due to the fact that the availability of financial information from Oman was limited due to the project reasons of the supplier company. For example, conducting interviews to the thesis with be'ah representatives was not possible and neither was requesting direct financial information and their assumptions. For this reason, the financial profitability calculations were based on known benchmarks and suppliers references. Also, some data was collected from public financial statements from Oman utility companies.

The weight coefficients of different decision-making criteria were also only rough estimates. This was due to the reason that because the interviews were not allowed by the supplier company, the selected criteria and their weights were not able to be validated by the be'ah representatives, as was the initial plan. However, the inaccuracy of the criteria and their weights were attempted to mitigate by utilizing iterative process to identify the criteria and their weights in three separate instances. The second iteration results stemmed from the additional information and deeper insight received during the visit to Oman, visiting the landfills, and discussing with different stakeholders in Oman. These results are presented in Table 10 below.

Table 10. *The second (2nd) iteration of decision-making criteria and their weight coefficients, categories and objectives*

Category	Criteria	Weight coefficient (1-5)	Objective (min/max)
Financial	Net present value	3	max
	Payback time	3	min
	IRR (project)	1	max
	Demand for side products	5	max
	Consumption of scarce resources	5	min
	Initial investment	4 → 3	min
Ecological	Waste disposal	5	max
	Environmental safety	4	max
	Low emissions	3 → 4	max
	Compact	1 → 3	max
	Waste hierarchy	2	max
Social	PR-value for be'ah and Oman (National and International)	4 → 5	max
	BAT	4	max
	Consumer preference	2	max
Utility	Availability	3	max
	Need for service	3	min
	Complexity	3 → 2	min

As can be seen from Table 10, the weight coefficients of initial investment, low emissions, compactness, PR-value for be'ah and Oman, and complexity are different from the values presented in Table 9 previously. According to the discussions and general message during the visit to Oman, the initial investment doesn't play such an important role as was previously thought and thus, its weight coefficient was lowered by one. The low emissions was extended to cover also the bad odor released from the waste. This odor issue was discussed in several instances and various stakeholders announced their concern regarding this issue. Also the leachate and its proper handling was discussed several times. Thus, the low emissions weight coefficient was increased by one. Compactness was also broadened to cover overall utilization of land area. The location and the area of the plant was a general concern in Oman and discussed in various instances. It seemed relatively important that the plant would be placed in a remote area and that it would be reasonably compact. Thus, this weight coefficient was increased by two. The PR-value was actually mentioned by its name and it seemed to be extremely important for both the local authorities and the be'ah representatives. Thus, it was increased by one to the highest weight coefficient. The complexity did not seem to appear as such as an issue since the high technology adoption in general and the overall willingness of the local authorities and be'ah. Thus, it was lowered by one.

The last iteration was generated by discussion and assessment with the representatives from the supplier company, university, and FMEA consortium in a workshop meeting, refining the information from the first and second stage. Thus, it can be assumed that those figures provide sufficient level of accuracy. These figures are presented in Table 11 below.

***Table 11.** The third (3rd) iteration of decision-making criteria and their weight coefficients, categories and objectives*

Category	Criteria	Weight coefficient (1-5)	Objective (min/max)
Financial	Net present value	3 → 4	max
	Payback time	3 → 4	min
	IRR (project)	1 → 4	max
	Initial investment	3	min
	Demand for side products	5 → 4	max
Ecological	Waste disposal	5	max
	Environmental safety	4	max
	Low emissions	4	max
	Consumption of scarce resources	5	min
	Waste hierarchy	2 → 1	max
Social	PR-value for be'ah and Oman (National and International)	5	max
	BAT	4	max
	Consumer preference	2	max
Utility	Compact	3	max
	Availability	3	max
	Need for service	3	min
	Complexity	2	min

As can be seen from Table 11, the weight coefficients of net present value, payback time, IRR (project), demand for side products, and waste hierarchy are different from the values presented in Table 10 previously. Also it is notable, that the consumption of scarce resources is relocated under the ecological group and the compactness is relocated in the utility group. This relocation of the two criteria does not alter the calculations, but it makes the table easier to understand.

The results from the third iteration are considered to be reliable enough for the simulation. However, the information is still very abstract and thus the margin of error is notable. Especially when actual interviews for the customers were ruled out from the study.

6.2 Decision-making assumptions

The assumptions are divided into financial assumptions and non-financial assumptions. The financial assumptions were used in profitability calculations and in the decision-making criteria setting. The non-financial assumptions were mostly used only in the decision-making criteria setting.

6.2.1 Financial assumptions for profitability calculations

Some assumptions were made in the profitability calculations in order to simplify and to enable calculations for different technologies. The assumptions and reasoning behind these assumptions are listed in this chapter. The financial assumptions are presented in the same order that the relevant figures appear in the profitability calculation spreadsheets.

The initial amount of waste was assumed to be the measured amount in 2012 in survey (be'ah 2013). In the survey it was assumed that the amount of waste would increase 5% annually. However, this was considered quite high annual increase and thus, in these calculations an annual increase of 1,5% was used, as the greater annual intake can roughly be seen to increase the feasibility of the alternatives to the landfilling. This increase can, however, be altered afterwards in order to conclude sensibility analysis. Also, it was kept constant for all the technology alternatives.

The gate fees were assumed to be zero for all of the technologies. This was assumed for two reasons. First, it would then be same for each technology and thus the relative profitability of each technology could be assessed. Second, be’ah is declared as the owner of the waste in Oman and thus it will not be paying gate fee for itself in case that it owns the processing plant, regardless the technology the plant or site represents. However, for the sake of sensibility analysis the gate fee was included as zero in the profitability calculations so that it could be changed if necessary.

The rent for the land for each alternative was assumed to be zero. This meant, that be’ah, or any other operator, would not pay monthly rent for the land that it operated on regarding these alternatives. This was assumed first and foremost because in the chapter five it was suggested that these alternatives could be located in same locations that be’ah already has its landfill operations. Thus, be’ah probably already owns this land and the cost of land could be argued to be zero. On the other hand, be’ah is also operating under government’s order and their total ownership and thus the required land could be provided for them. On top of this, the initial investment is considered to include the facilities, making be’ah the owner of these facilities. Thus, as the owner be’ah would not pay rent but rather depreciate the investment. This zero rent assumption was issued on all alternatives, including the landfilling sites. However, for the sake of sensibility analysis the rent was included as zero in the profitability calculations so that it could be changed if necessary.

To enable continuous operation over a long period of time and to meet the demands of annual waste amount growth of 1,5%, some revision costs were also included for each technology. In general, revision costs were set to be quite high compared to the initial investment and other costs. In addition, they were timed to occur every fifth year so that the last revision would cover the last five years before decommissioning the plant or site. On top of this, there was one greater revision in the middle of the investment's lifetime, which could be also considered as mid-life update. The revision costs for power plants are quite self-explanatory, including enhancing efficiency and replacing dated technology and just repairing some more major components. For the landfills, however, the revision costs were considered to be the cost of a new landfill investment. For the landfills it was then assumed, that they would be needed to replace with a new one every fifth year since the old one would be filled up. For this reason, the landfills do not have the mid-life update higher revision costs. Also, due to the nature of the profitability calculation template, only the first landfill is considered as an investment and the rest are considered as costs. This creates some inaccuracy to the profitability calculations, but can be taken into account in the analysis.

In each technology alternative there were included "Other fixed" and "Other variable" costs. These were general costs that were not exactly recognized but were included to be on the safe side. These costs could include, for example, the salaries of management, unexpected service, or other fixed or variable costs that were not taken into account elsewhere in the calculations.

Landfilling tariffs were also assumed to be zero for all the alternatives. This meant, that for example landfilling the fly- or bottom ash from different boilers would not generate costs. Also, landfilling rejects from mechanical recycling would not generate costs. This was assumed for all of the alternatives to make them equal in terms of disposing the rejects, ash, and landfilled waste itself. On the other hand, as be'ah was considered to be both the owner of the technology, waste and landfills, it was assumed that the possible costs would remain as internal costs and thus all costs would cancel each other out.

The recycling income from both ferrous and other metals was considered to be [X €] per ton. This was assumed for all of the alternatives. However, some alternatives could not produce recycled metals. Also, it was assumed that the SRF line could recycle around [X %] of the metals before incineration. On the other hand, [X %] separation of metals was assumed for the mass incineration from the bottom ash. This latter is not entirely the truth, but as mass incineration is seen as the competitor of SRF, it was assumed so to make the competitor appear more feasible against the SRF line and thus to be on the safe side in the calculations.

The amount of fly- and bottom ash was combined to make the calculations simpler. Also, the total amount of ash was assumed to be [X %] in mass of the initial fuel mass. However, the amount of ash played only a small role in the profitability calculations, since the cost of landfilling the waste was set to zero. Also, the logistics costs of landfilling the ash was not set to any specific value, since the plant could be located next to the landfill, as discussed previously in this text. On the other hand, the cost of landfilling the ash could be included in the “other variable costs” in the profitability calculations, as that cost was reserved for other, unexpected costs.

Sales revenues were assumed separately for each technology. The electricity tariffs were sourced from *My e-portal* (EHC 2015). The price of the produced potable water was set according to internal Eera consulting company source. The cooling revenue was set to match the similar district cooling and heating revenue in Finland (Turku Energia 2015). The revenue and the amount of landfill gas was set according to literature by methane gas amount and market price per megawatt hour (U.S. Environmental Protection Agency 2015). For all of the revenue components it was assumed for the sake of simplicity, that there would be [X %] demand and all that was produced could be sold. This was, however, taken into account in the actual decision-making simulation with criteria “Demand for products”.

As the be’ah is operating under government’s order and providing a public service, it is probably receiving some subsidies from the government or society. However, as no accurate information about these subsidies was available, it was assumed that subsidies were paid per ton of waste processed and that the subsidies were also zero euros per ton. In reality, be’ah must receive some income from the processed waste. However, the zero amount served the purpose of comparing different alternatives, as the standard subsidized amount would probably remain the same for each technology per ton of processed waste. On the other hand, there might exist some incentive in the form of subsidies to process the waste more environmentally friendly, and thus the subsidies were included as zero in the calculations to enable the possible later sensitivity analysis.

The operating expenses, consisting usually of wear and spare parts, labor costs, energy costs, service costs, and co-fuel costs were assumed by case and in general, those costs were set by the best and reasonable estimate, as no more accurate information was available. For example, in labor cost the average worker salary and other worker related expenses, such as social security expenses, were assumed. Then, the total amount of workforce was estimated per case. All in all, all these operating expenses were also considered to increase with the annual increase in the waste amounts.

All the calculations and assumptions were carried out in euros. This was due to the reason that euro was more familiar to the author and researcher as a currency and thus the assumptions about different prices and costs were more reliable when presented in euros. Also, the most important goal of the profitability calculations was to enlighten the relative difference between different investment alternatives, not to predict and analyze the exact and absolute future profitability. This means, that the inaccuracy in the calculations is tolerated, since the main focus is to figure out the differences between alternatives. On the other hand, the annual costs and revenues were estimated quite accurately according to the literature and other reference cases. However, the most inaccurate component in the profitability calculations was unmistakably the initial investment amount. The true investment costs was extremely difficult to assess, as even the final location of each alternative was not fixed. Thus, the investment amounts were based on the known reference plant in [a country]. The investment of this plant was [X €] and the plant handles [X tons] of municipal waste per year and produces SRF fuel and then incinerates it in the fluidized bed boiler. Another known investment case was in [a country]. This investment was [X €]. The plant handles [X tons] of municipal solid waste by mass incineration. The electricity and heat outputs were also known. Thus, the relevant investments were scaled according to these investments. Other investments, such as landfills and gasification plants were based on these investments, but were a great deal more inaccurate since relevant reference investment of same technology was not known.

The profitability analysis on the technology alternative 2 was based solely on the difference or impact of the implementation of SRF line on an existing technology alternative 2 plant, as this is usually the case. This meant, that the investment was significantly lower, as only the SRF related investment needed to be conducted, whereas in the case of, for example, the technology alternative 1 it was assumed that the investment also covered other relating components.

In all profitability calculation the discounting factor was set to 2% and the beginning of the investment period was set to the beginning of the year 2016, however, with the measured 2012 waste amounts. The investment time period was set to 30 years, as this is quite normal holding time for energy industry related plants. However, due to the long holding time revision costs were also taken into account and those occurred every fifth year, the containing one larger revision in the middle of the holding time.

6.2.2 Non-financial assumptions

One of the criteria selected was consumption of scarce resources. Potable water is one scarce resource in Oman and the bio gasification technology consumes great amounts of fresh water and produces sludges. For this reason it was seen that it could be ruled out from the options.

Waste disposal was one another selected criteria. Technology alternative 7 received the best scores on this criteria. For example, producing SRF in a SRF line produces also rejects, which still need to be landfilled. Also, the incineration, both SRF and mass incineration, or gasification process all produce ash which needs to be further landfilled. On the other hand, using SRF in cement kilns binds the ash into the produced cement and thus the waste disposal score on cement kilns was higher than other incineration technologies'.

Low emissions meant mainly the overall efficiency of the process, since in comparison of the technologies the total waste would be the same and thus, when incinerated, would release the same amount of emissions. Also, cleaner incineration would help to reduce the amount of, for example, hazardous NO_x, CO, or SO_x, components in the flue gas.

The compactness criteria was based on an assumption, that it would be beneficial to strictly center and border the area where the waste processing would happen. This is to limit the negative impact to other surrounding areas. Negative impacts could be, for example, rodents and diseases carried by the said rodents, displeasing odor, birds and rodents spreading the waste to surrounding areas, and groundwater contamination. An ideal compact plant could be, for example, a plant that received the waste in closed containers and all processing would happen indoors in the plant facilities. The output would then only be the bottom ash in, again, closed containers and well filtered and cleaned flue gas.

Waste hierarchy was brought to the criteria since it was assumed that it represents the current political and social willingness and state of purpose in the waste management in developed countries. Thus, it was seen important to be a part of the decision-making. However, as the waste hierarchy is more centered in the reusing and reducing the waste and that was not the scope of this thesis and none of the selected technologies are able to answer well to these demands, it was given quite a low weight value.

The three selected social aspect criteria were assumed to represent the three different stakeholders' opinions over the same phenomena. The PR-value for be'ah and Oman represents the opinions of other companies and nations or other organizations or entities. By assumption, the more sophisticated waste management system be'ah and Oman are able to implement, the more they present themselves as in a role model's position for other parties involved. This might have a beneficial effect on Oman as a whole or for be'ah alone by, for example, increasing exports and creating demand for the waste management know-how that be'ah has developed. The BAT, or Best Available Technology, criteria measures the internal satisfaction with the selected technology and waste management strategy. It was assumed, that Oman and be'ah are interested in acquiring the best available technology and bringing the waste management in Oman up to date and thus this criteria was given a quite high weight coefficient. The last social criteria, Consumer preference, measures the consumer acceptance and preference of different technologies. The best available technology might not present itself as the most preferred to laymen or ordinary consumers, even though the industry specialists would favor it. Thus, the values regarding different technologies might vary from other two social criteria mentioned before. This criteria was also given a quite low weight coefficient.

The last three criteria are Availability, Need for service, and Complexity. These are focused on assessing the utility and ease of use and implementation. It was assumed, that the simpler the processes were to run and implement, the more favorable they would be. This included also the aspect of service and availability. Low availability might stem from the constant breakdowns and unscheduled need for service due to unreliable technology or wrong overall operating parameters or solution. On the other hand, constant service, even if scheduled, requires more effort and thus makes the running and operating the plant or technology itself more complex. Furthermore, the more complex the technology itself is to implement, the more be’ah needs to do groundwork before smooth operation could be achieved. This could mean, for example, educating plant workers, building infrastructure, and establishing a totally new supply of certain spare parts or service operations.

Lastly, regarding the low weight coefficients of the financial criteria, it was assumed that the primary or key drivers for this waste management renewal undertaking is not monetary, but rather purely the need to answer to the increasing amount of municipal waste. Also, the need to achieve a sustainable waste management throughout the Sultanate of Oman was seen more important. This idea was visited, for example, in power point presentations in 3rd International Conference for Waste Management in Oman and in be’ah’s vision on their website (Said 2014; be'ah 2015). Also, as an oil and petroleum industry nation, Oman has the needed funds for such a governmental undertaking. Thus, the economic feasibility, although important, was not seen as the most important driver in the decision-making.

6.2.3 Ecological, social, and utility values per criteria per technology alternative

The ecological, social, and utility values were more or less technology-dependent, as the financial values depended from both the technology and the location specific parameters, such as the amount and quality of the waste and demand for side products. For this reason, the ecological, social and availability values were set to the same values per technology, regardless the location. This chapter covers the setting of these values per criteria. The Table 12 below illustrates the given points per technology alternative per criteria. Initially the values were given by the author and then validated at the professional workshop.

Table 12. *Points per technology alternative per ecological, social, and utility criteria*

	Weight	Technology alternative 1	Technology alternative 2	Technology alternative 3	Technology alternative 4	Technology alternative 5	Technology alternative 6	Technology alternative 7
Waste disposal	5	3	4	3	3	2	3	5
Environmental safety	4	4	5	4	4	2	3	1
Low emissions	4	4	4	4	4	4	4	3
Consumption of scarce resources	5	1	1	1	1	1	1	2
Waste hierarchy	1	3	4	3	3	3	2	1
PR-value for be'ah and Oman (National and International)	5	4	3	5	5	4	2	1
BAT	4	4	3	4	4	5	3	1
Consumer preference	2	3	2	5	5	3	2	1
Compact	3	3	4	2	2	2	5	2
Availability	3	4	4	3	3	3	4	5
Need for service	3	4	2	5	5	5	5	1
Complexity	2	4	3	4	4	5	2	1

Waste disposal was seen as very important objective of the total process. Thus, it was set the highest weight coefficient. Technology alternative 1, technology alternative 3, and technology alternative 4 were set to 3 on this criteria. This was due to the relatively high incinerated mass percentile. The same value was set technology alternative 6 as well, since the amount of ash can be considered to be approximately the same. Technology alternative 2 gets rid of the ash, and thus this technology received higher points. Technology alternative 5 received relatively low points due to higher output of solids. Technology alternative 7 received the highest points, since in terms of only disposing the waste, it succeeds to dispose 100% of the waste in one simple process.

Environmental safety received the second highest weight coefficient, 4. Again, technology alternative 1, technology alternative 3, and technology alternative 4 were set to the same value, this value being 4. The technology alternative 2 received the highest points, as it binds the ash into an insoluble form so that the chemicals in ash can no longer pose threat to environment. Technology alternative 5 received 2 points, as the ash it produces is slightly more heterogeneous due to lesser incineration or thermal processing efficiency. Technology alternative 6 received 3 points, as the bottom ash contains all noncombustible components of the input waste, including metals and rejects. The technology alternative 7 received 1 point, as it is a major threat to the environment, possessing potential for various harmful scenarios for society and environment.

Low emissions received also quite high weight coefficient, the value being 4. Technology alternative 1, technology alternative 2, technology alternative 3, technology alternative 4, and technology alternative 5 received 4 points on this. This is due to the higher incineration efficiency, lower incineration temperatures and lower emissions. Due to the advanced flue gas treatment technologies, however, the technology alternative 6 also received 4 points. Technology alternative 7 received 3 points, as in ideal situation it produces virtually no emissions. This, however, means that there is no, for example, process problems. As this is not the reality, the performance score is lower.

Consumption of scarce resources was seen as very important criteria. All other technologies except the technology alternative 7 received the lowest score, 1, as those were not seen to consume high amounts of natural resources. The technology alternative 7, however, will consume more land. Also the technology alternative 7 might cause danger for soil and groundwater and, as was seen on site, consume a lot of water for fire extinguishing.

Waste hierarchy was seen also as a low priority criteria and thus it received the weight coefficient of 1. The reason the waste hierarchy, although important in ecological sense, was set to low priority was that the main focus and willingness of the be’ah and Oman was to solve the waste problem as ecologically as possible. This did not contain the willingness to directly structure the waste management system according to the waste hierarchy defined by EU. Technology alternative 1, technology alternative 3, technology alternative 4, and technology alternative 5 received 3 points due to the recycling of different waste fractions. However, technology alternative 3 received 4 points, as the ash is reused, which is higher in the waste hierarchy. Technology alternative 6 received 2 points, due to lack of recycling and lower efficiency. Finally, technology alternative 7 received 1 point.

The PR-value for be’ah and Oman represented the external organizations’ attitude towards the selected technologies and the value be’ah and Oman could source from this attitude. As this might even generate new business, this received highest weight coefficient. The technology alternative 1 scored 4 points, whereas the technology alternative 2 scored 3 points. This was because technology alternative 1 has more uses than technology alternative 2. The technology alternative 3 and technology alternative 4 received 5 points, as the technological complexity and the visibility of the output increases. The value of their outputs can be actually experienced and noted more easily. Technology alternative 5 received 4 points, for the similar reasons than the technology alternative 1. Technology alternative 6 received 2 points, as it is less efficient and does not contain recycling. Finally, technology alternative 7 received one point, as it is the least favorable in ecological sense and thus does not really promote new business or favorable visibility.

The best available technology, or BAT, represented the internal attitude towards the selected technology. These points were mainly the same as external ones, but there were some exceptions. Technology alternative 3 and technology alternative 4 received 4 points.

This was due to the reason that those are relatively dated technologies. However, the technology alternative 5 received 5 points. This was because it is relatively new technology and could lead to further refining of outputs. Technology alternative 6 received 3 points, as the technology in that area has developed as well and the overall control of emissions and, for example, flue gas washers and filters represent quite state-of-the-art technology.

Consumer preference represented the external attitudes of normal consumers and citizens towards selected technologies. This was very similar to the attitudes of external organizations. However, it contained some minor differences since the consumers' view is fundamentally different from organizations'. Also, the weight coefficient of the consumers' preference was relatively low, being only 2. The technology alternative 1 received one point less, scoring 3 points. The technology alternative 6, on the other hand, received 2 points, as it might have a slightly negative tone in the consumers' ear, especially when no recycling is performed. Still, both of these technologies still produce greenhouse gases, albeit mostly from renewable materials, causing the difference to narrow down to only one point. Technology alternative 5 scored one point less, scoring 3 points. Also the technology alternative 2 scored one point less, scoring 2 points. This was due to the reason that the output is not really visible to the consumers and, once again, greenhouse gases are produced.

All in all, the scoring of the social criteria per technology was more or less inaccurate and estimate based, since real surveys about the opinions were not possible to conduct. Thus, the estimates were based on the willingness deductible from the be'ah PowerPoint presentations (Said 2014; Tarik 2014). Also, the subject is extremely intangible and abstract.

Compactness was seen as a medium importance criteria. Thus, it received 3 as a weight coefficient. Technology alternative 1 received 3 points and this was used as reference point for others. Technology alternative 2 received 4 points. Technology alternative 3 and technology alternative 4 require in additional processing plants and processing equipment, and thus those both received 2 points. Also technology alternative 7 and technology alternative 5 received 2 points, since storing the waste requires space, was it either for the final storage or for composting purposes. Finally, the technology alternative 6 received 5 points.

The availability scored 3 in weight coefficient. The technology alternative 1 and technology alternative 2 scored 4 in the availability. This was due to the reason that the technologies are relatively reliable in both and the fuel can be retrieved from storage, which increases the availability. The same applies for technology alternative 3, w technology alternative 4 and technology alternative 5. However, those technology alternatives contain also other components, which have their own availability and thus that lowers the overall availability, resulting them to score 3 points. Technology alternative 6 received also 4 points, placing it on the same level of availability as the technology alternative 1. Finally, technology alternative 7 received 5 points, as it is always available.

Need for service depended on the technological complexity and the probability to failure and scored 3 in the weight coefficient. Technology alternative 2 received 2 points. This functioned as reference point. Thus, technology alternative 1 received 4 points. Technology alternative 3, technology alternative 4, and technology alternative 5 all scored 5 points, as those contain even more components which need to be serviced separately. Technology alternative 6 also scored 5 points, mainly due to the fact that it is prone to blockages and contamination. Finally, technology alternative 7 scored 1 point, as the service need is mainly focused on the vehicles operating at the site and that has little effect on the technology as a whole.

Complexity meant the technological complexity, which caused the implementing or utilizing the technology to require more effort. The complexity was not seen as quite an important criteria and thus it scored 2 in the weight coefficient. Thus, technology alternative 2 received 3 points and it functioned as a reference. Technology alternative 1, technology alternative 3, and technology alternative 4 received 4 points, as the implementation would require some education of the workers and building some infrastructure. Technology alternative 5 received 5 points, as it requires implementation of multiple technologies, some of them being fairly complex. Technology alternative 6 received 2 points, as it is quite low level technology for the operators. Finally, technology alternative 7 received 1 point, as it requires hardly any education or causes minimal requirements for implementation.

6.3 Comparison of alternative concepts per location

A comprehensive table of the estimated values of each alternative per criteria for decision-making simulation is given in the appendix 5 separately for each iteration of identification. This chapter covers the reasoning behind the selection of alternatives per location and how the values per financial criteria were selected.

In Table 13 below are listed the proposed investment alternatives per location. The main focus was on Salalah, Muscat, and Sohar-Yanqul. This was due to the reason that Al Kamil and Adam locations produced only a small amount of waste per year. This can also be seen in Figure 13, which is presented earlier in this thesis.

Table 13. *Investment alternatives per location*

Salalah	Al Kamil	Muscat	Sohar-Yanqul	Adam
Technology alternative 1	Technology alternative 7	Technology alternative 1	Technology alternative 1	Technology alternative 7
Technology alternative 3	Technology alternative 5	Technology alternative 3	Technology alternative 3	Technology alternative 5
Technology alternative 4		Technology alternative 4	Technology alternative 4	
Technology alternative 2		Technology alternative 2	Technology alternative 2	
Technology alternative 6		Technology alternative 6	Technology alternative 6	
Technology alternative 7		Technology alternative 7	Technology alternative 7	
Technology alternative 5		Technology alternative 5	Technology alternative 5	

Technology alternative 5 combines three different technologies to one process. One of these technologies is the same as technology alternative 7.

6.3.1 Salalah

Seven investment alternatives were proposed for Salalah location. These alternatives are listed in Table 13, presented previously in this text. These technology investment alternatives are similar to the technologies previously presented in chapter 4.

However, in chapter 4 there were also presented separation and recycling or sorting in origin of waste, bio drying, and bio gasification. As these are not directly mentioned in the investment alternative list, it is necessary to discuss why those were left out from the alternatives' listing. First of all, the separation and recycling/sorting in origin of waste is something that is done already, since municipal waste, park & garden waste, slaughter waste and industrial waste are collected separately. On the other hand, this separation could be more precise and include also separation of different fractions of municipal waste, such as metals, glass, paper and carton, or plastics. Nevertheless, sorting and separating in the origin of the waste will not lead into final waste disposal, which is the objective of the actual technology alternatives. Thus, it is not included in the alternatives. Bio drying is considered to be an auxiliary component that can be installed on any of the SRF based technologies, even afterwards or as part of a mid-life update or other revisions. Thus it was not treated as a separate alternative. Bio gasification is ruled out completely, since it consumes a great deal of water and produces sludge. As water is scarce resource in Oman, and the thermal gasification can also gasify the organic matter, it was decided that only one gasification technology would suffice for the purposes of this thesis.

Some profitability calculations for each technology alternative were carried out. These results were later utilized in the decision-making simulation.

As mentioned before, the net present value calculated does not represent the actual net present value for multiple reasons. For example, the gate fee and subsidies were set to zero. Also, the cost for landfilling was set to zero and all of the other parameters were more or less estimates, as more accurate information was unavailable. However, the net present value represents the relative difference in the profitability between the alternatives, as the inaccuracy and estimates were same for each technology alternative.

Profitability figures were scaled to scale between 0-5 for the ELECTRE and Weighted Sum methods inputs, 0 being the value in case the investment never paid itself back or the IRR was unable to calculate.

The results for Weighted Sum Method and ELECTRE III multi-criteria decision-making simulations for Salalah is presented are Table 14 below. The results are listed in order of preference, the most preferred alternative as first.

Table 14. *Salalah Weighted Sum Method and ELECTRE III results*

	Weighted Sum Method	ELECTRE III
1.	Technology alternative 2	Technology alternative 2
2.	Technology alternative 3	Technology alternative 3
3.	Technology alternative 4	Technology alternative 1
4.	Technology alternative 1	Technology alternative 4
5.	Technology alternative 6	Technology alternative 6
6.	Technology alternative 5	Technology alternative 5
7.	Technology alternative 7	Technology alternative 7

As can be seen from the Table 14, the technology alternative 2seems the most favorable to Salalah in both simulation tools, even though it is only third in profitability in terms of net present value. This is understandable, as the technology alternative 2 disposes the waste efficiently, is environmentally friendly, profitable, and there is demand for the side products in Salalah. Other promising technologies are technology alternative 3 and technology alternative 4.

The customer, in this case be'ah, was estimated to value the criteria according to their weights. As there was no way to conduct interviews or in customer focus groups, as Anderson & Narus suggest in their text, the value identification was limited only to viewing the market outside in, as defined by Kothari & Lackner (Anderson et al. 2006; Kothari & Lackner 2006). However, the actual selected criteria were quite basic and standard for the industry. On the other hand, the weight coefficients of each criteria might contain some inaccuracy due to the limited methods. The scoring of different technology alternatives per criteria was more or less based on both the known technology competences and abstract willingness and thus it is considered that the more tangible criteria are scored more reliably than the ones containing estimates about customer's abstract motive.

6.3.2 Al Kamil

There were only two compared technology alternatives selected to Al Kamil. This was due to two reasons. First of all, the annual waste amount was very limited. This renders some technology concepts unnaturally unprofitable, as the economies of scale do not realize. Thus, the technology investments have some form of meaningful minimum capacity. Secondly, as the annual waste amount in Al Kamil and Adam was clearly below the meaningful level for most technologies, it was decided that the decision-making simulation would be simplified by leaving the unfavorable technology alternatives out for both of the locations.

Table 15 below presents the results of Weighted Sum Method and ELECTRE III method for Al Kamil. Results are presented in their order of preference, the most favorable being the first.

Table 15. *Al Kamil Weighted Sum Method and ELECTRE III results*

	Weighted Sum Method	ELECTRE III
1.	Technology alternative 5	Technology alternative 5
2.	Technology alternative 7	Technology alternative 7

The evaluation of technology alternative 5 alternative relied heavily on the possibility to downscale the investment. However, if it was possible, the technology alternative 5 seems to prevail over technology alternative 7 in the decision-making simulation. However, more precise research about the possibility to downscale the technology alternative 5 should be conducted in order to assess its true feasibility. Thus, it would probably be safer to select the technology alternative 7. This is also because of the very small annual waste amount.

6.3.3 Muscat

As can be seen from the Table 13, the same seven technology alternatives that were proposed to Salalah were also proposed to Muscat. However, as the annual waste amount was more than double compared to the Salalah annual waste amount, the profitability analysis differed. In general however, the initial investments were set to roughly the double of the Salalah investments. Also, majority of the other parameters were roughly the double. However, for example, the amount of lime in the additives were estimated according to the specific Muscat defined waste composition and amount. All in all, the values were quite rough scaled up estimates of the Salalah values. However, even if the waste intake was more than double, some economies of scale were estimated to be achieved. Thus, for example, the initial investment is not scaled up in one-to-one ratio.

The initial investment of the electricity alternative was based on a known investment case of a similar size and technology. This was used as a primary reference point for the other technologies and locations. The Mass incineration technology alternative initial investment was also based on a known investment case. The results of decision-making simulation with Weighted Sum Method and ELECTRE III tool are presented in Table 16 below.

Table 16. *Muscat Weighted Sum Method and ELECTRE III results*

	Weighted Sum Method	ELECTRE III
1.	Technology alternative 3	Technology alternative 2
2.	Technology alternative 2	Technology alternative 3
3.	Technology alternative 4	Technology alternative 4
4.	Technology alternative 1	Technology alternative 1
5.	Technology alternative 7	Technology alternative 5
6.	Technology alternative 5	Technology alternative 6
7.	Technology alternative 6	Technology alternative 7

The Muscat results are similar to Salalah results. The technology alternative 2 prevailed over technology alternative 3and technology alternative 4 technologies by scoring higher points in waste disposal and environmental safety, as these criteria were weighted heavily in ELECTRE III method. However, in Weighted Sum Method the technology alternative 3 prevailed over the technology alternative 2.

6.3.4 Sohar-Yanqul

Sohar-Yanqul was proposed with the same seven technology alternatives as Muscat and Salalah. This is due to the reason that the Sohar-Yanqul area was similar to Salalah area, having the similar amount of annual waste. However, a notable difference was in the waste composition, as the Sohar-Yanqul area has much more greater industrial waste component in its annual waste stream. This can also be seen from the Figure 13. This is due to the reason that there is greater industrial area in Sohar-Yanqul than in Salalah. For this reason the calorific value of the overall waste in Sohar-Yanqul area was assumed to be greater, than in Salalah.

The initial investments are similar to the Salalah investments. The results for the Weighted Sum Method and ELECTRE III decision-making simulation can be seen in the Table 17 below.

Table 17. *Sohar-Yanqul Weighted Sum Method and ELECTRE III results*

	Weighted Sum Method	ELECTRE III
1.	Technology alternative 2	Technology alternative 1
2.	Technology alternative 3	Technology alternative 2
3.	Technology alternative 4	Technology alternative 3
4.	Technology alternative 1	Technology alternative 4
5.	Technology alternative 5	Technology alternative 7
6.	Technology alternative 7	Technology alternative 5
7.	Technology alternative 6	Technology alternative 6

As suspected, the lack of demand for the end products of technology alternative 2 and its higher initial investment affects its placement on the list in case of ELECTRE III tool. However, the same effect is not visible in the Weighted Sum Method.

6.3.5 Adam

Decision-making simulation, underlying values in profitability analysis and results for Adam are very similar to Al Kamil. This is due to the reason that the annual waste amount was of the same scale in both locations. Also, the municipal waste composition was similar. In Adam as well as in Al Kamil the total annual waste amount was considered not to be sufficient to justify investment on large scale incineration processes. This was assumed on the basis of the report by Rand et al. (Rand et al. 2000). In their report they suggest that the incineration process shall only be feasible if the annual amount of combustible waste exceeds 50 000 metric tons (Rand et al. 2000). However, the technology alternative 5 was included as in Al Kamil. This, however, relied heavily on the possibility to downscale the investment greatly. Below in Table 18 are presented the Weighted Sum Method and ELECTRE III decision-making simulation results for Adam.

Table 18. *Adam Weighted Sum Method and ELECTRE III results*

	Weighted Sum Method	ELECTRE III
1.	Technology alternative 5	Technology alternative 5
2.	Technology alternative 7	Technology alternative 7

As can be seen from the Table 18, the results are equivalent to the results from Al Kamil. However, the applicability of the technology alternative 5 needs to be verified. As this is out of the scope of this thesis and decision-making simulation, it is only assumed that technology alternative 5 process is able to be scaled down sufficiently to maintain feasibility for the purpose of waste management in Adam and Al Kamil.

6.3.6 Summary

By simulating the customer’s decision-making the supplier can get deeper insight about the customer’s point of view. This is due to the reason that to succeed in simulation, the supplier is forced to analyze the customer’s alternatives and to identify the components that the customer values and even to evaluate the importance of different value components. This can reveal some repeating patterns, that else would possibly have even left unnoticed. However, the simulation must be based on an objective and reliable data, else the simulation serves no purpose.

In this case, two quantitative multi-criteria decision-making tools were used to simulate customer’s behavior or decision-making. These two tools were Weighted Sum Method and ELECTRE III. The data for these decision-making tools was prepared in three separate iterations, involving background research, onsite presence and hands-on experiences, and professional workshop. This method was assumed to result into a relatively accurate and reliable data for decision-making simulation, even though the actual interviews for customer were ruled out due to the project reasons out of the scope of this thesis.

The simulation results were quite clear. Some variation between the methods was observable, however the general message about the most favorable technology concepts was well represented. In Salalah, Muscat, and Sohar-Yanqul locations the technology alternative 2 was always either the first or the second most favorable technology concept, regardless of the multi-criteria decision-making tool used. In these locations the technology alternative 1, technology alternative 3, and technology alternative 4 concepts filled the other remaining positions of the four most favorable concepts, in varying order. Thus, it was seen that the technology alternative 2 received strong arguments to be the most favorable technology concept for the waste disposing, the other most favorable concepts relying also on similar fuel solution with local differences depending on demand of the outputs of, for example, technology alternative 1, technology alternative 3, and technology alternative 4. For the locations of Al Kamil and Adam the most favorable concept was technology alternative 5, followed by the technology alternative 7. However, as discussed previously, this relies heavily on the ability to downscale the technology alternative 5 plant to make it economically feasible.

All in all the simulation was seen to give important information about the most favorable technology concepts for the customer. This helps the supplier company by increasing the understanding about what the customer values and what kind of decision-making process they might go through. Also, the simulation could prepare the supplier company with arguments for and against some technology concepts, so that they could be more ready to participate in discussions with the customer.

7. BUSINESS MODEL CANVAS GENERATION

In this chapter a business model for the supplier company is created for the market area of the Sultanate of Oman. The business model is aimed to function as a basis for the possible future extensions to the neighboring countries as well. As discussed previously, the framework of Business Model Canvas is used to present the business model. Also, the increased knowledge from the customer's decision-making simulation executed in the previous chapter is utilized in creation of the business model.

Due to the nature of the supplier company's business, some parts of the Business Model Canvas are discussed in more depth and some parts are left for more general or overview illustration. Also, only one business model is created for the entire Sultanate of Oman, meaning that the business model covers all the five locations that this thesis has previously discussed. Thus, the business model is not going to be a tool for individual sales, rather than a tool to truly create and land new business on the mentioned geographical area.

7.1 Assumptions for building blocks

The business model was generated for the supplier company. Thus, as the supplier already has a functioning business and the new business model was mostly generated for a new geographical area, some parts of the business model are derived straight from the supplier company's existing business practices. In the Business Model Canvas these are the segments of Key Partners, Key Activities, Key Resources, Customer Segments, Customer Relationships, and Channels. Also, the cost structure is more or less adapted from the existing business in other global markets. The remaining parts, Value Propositions and Revenue Streams are more or less case specific, the main focus being on the Value Propositions.

It was also decided, that the business model will focus on the three largest locations, Salalah, Muscat, and Sohar-Yanqul. Thus, the two smaller locations, Al Kamil and Adam will be considered less and the needs of these locations will weigh less in the final business model presented in Business Model Canvas.

7.2 Business Model Canvas

This chapter describes the final Business Model Canvas in the sub-chapters. Each sub-chapter represents a separate segment in Business Model Canvas. The Business Model canvas is presented in appendix 6.

7.2.1 Key partners

There are a few identified key partners that are case specific. Also, there are key partners that stem from the normal business of the supplier company. The case specific key partners are a few separate consulting parties. Two are promoting the business in the targeted geographical area and have been developing contacts to the promising supplier industry in Finland and to the probable customers and decision-makers in targeted geographical area. These two consulting parties are also, although separate parties, co-operating with each other. The third consulting party is a technical consulting company specialized into technology alternative 2 process.

On top of these case specific consulting partners there are some partners that are already partners in some other businesses the supplier has. These are typically, for example, subcontractors, that supply some equipment for the supplier company. Partners could also be construction companies or local entrepreneurs specialized in machinery installations.

The key resources acquired from the case specific consulting partners are contacts and knowledge about the market. Also, the consulting parties have been cooperating in founding a new company to the targeted geographical area to function as the customer for the supplier company. This customer will also be one type of key partner. The more technical consulting company provides a solution and analysis for the necessary actions and results for the technology alternative 2 implementation. The subcontractor partners, construction companies and machinery installation companies are used to outsource the operations that are not the core competence of the company. The supplier company manufactures some machinery itself, but the majority of the machinery is outsourced.

7.2.2 Key Activities

Problem solving and designing are the most important activities that the supplier company does in its business. By solving the problems the customer has, the company can design a working plant layout and outsource and manufacture the necessary machinery and conveyors. Contacting the subcontractors and ensuring project success are the other main activities of the supplier company. Some manufacturing is also performed by the supplier company, however even the manufacturing is more or less only assembling the key machinery from outsourced components at the supplier company’s facilities by own staff.

This specific case does not really require new case specific activities from the supplier company, other than close co-operation with the new contacts and the mentioned consulting parties. Thus, the problem solving, designing and project management will still be the most important activities, assembly and manufacturing being second important activities.

7.2.3 Key Resources

The supplier company operates on a business area, which is quite resource intensive. First and foremost the machinery needs to be manufactured and installed. This requires raw materials and labor hours. The labor force needs to also be skilled due to the fact that some the machinery is very specialized and, for example, the structural strength is a key factor and that depends heavily on the manufacturing process, errors in the manufacturing, and the overall skill of the manufacturing labor force. Also, the design of such a robust machinery and designing the finished layout from the given components to satisfy the customer's needs requires also high intellectual capacity. Thus, the human resources are also important, both in manufacturing and design.

The investment is also quite significant. Due to the reason that the customer rarely pays the whole investment up front, the supplier company has to carry the bill of materials and work for quite some time. This requires high capital resources, in order to the supplier to survive and to be able to deliver the customer the whole project and to wait for the customer to pay. However, these resources are all very similar to all the other business cases the supplier company already has and thus, they are not case specific.

7.2.4 Customer Segments

The customer segment is very narrow for the supplier company. The customers are companies that are willing to invest in waste processing line to create SRF from the waste. Thus, individual consumers and majority of companies are ruled out. The segment can be thus understood as niche segment.

In this case at least one customer is created to the market and further co-operation with this customer could be considered. However, it might appear that in this geographical location the customers will be relatively similar to the other customers the company already has in other global locations.

7.2.5 Customer Relationships

In the case of created customer, the customer relationship is going to be very close. This is due to the very good relations between individuals in these organizations. As the purpose is to land new business in this geographical area in a more macro sense, it will be rational to put a great deal of effort in the customer relationships in this area to create stellar reference plants, at least for the beginning.

The customer relationship should be dedicated to certain persons in the supplier company and the focus should be in co-creation. The service sales and operations should be proactive from the supplier company to increase the sales and customer profitability but also to ensure the good performance of the customer's plant.

7.2.6 Channels

The sales will be executed through personal contacts and negotiations will happen mostly in person. This is normal for transactions and projects of this scale. The machinery deliveries on site will happen through selected logistics operators and the assembly on site will most likely be outsourced to local companies, while the supervision will be provided by the supplier company. After the delivery the customer relationship will be managed by dedicated personnel and the relationship will be kept close to promote aftersales and to enable good reference plant value and also to learn from the local conditions.

Due to the nature of the supplier's business, there will be no online or physical store, at least for a while, for the customer to visit and to purchase what they need. Thus the personal sales contacts are extremely important. Later, when there are more customers in the targeted geographical area, it would probably make sense to invest into a wear and spare parts warehousing to make service more efficient. Also, some local contracts could be struck to manufacture certain spare parts. The service operations will be outsourced to local entrepreneurs under a supplier company's license.

7.2.7 Value Propositions

Customer value is estimated in the customer decision-making simulations. The value components were selected as criteria and those were weighted according the best available knowledge and understanding about how the customer values each component. After that the alternatives were scored to the each criteria or value component. Thus, the customer's decision-making simulation estimates quite reliably the customer perceived value and value propositions.

The value proposition is case specific as it was based on the customer's decision-making simulation. This should be executed in future as well, to ensure the best understanding about the value proposition to the customer. The method also forces the supplier to identify the value components and assess their relative weights. After that, the performance or value of each individual alternative is assessed.

The main customer value will be focused on the utilization of the SRF fuel. This has two most important outcomes. First of all it substitutes the current fuels, which typically are fossil fuels. This further results in the lower fuel costs and, on the other hand, lower emissions. The other main outcome is, that the fuel could be extra to the strictly controlled fossil fuels. This is important, as the fuels in Oman are under strict control and this control might cause some pressure and inhibit otherwise favorable growth.

The other important customer value aspects are the waste disposal, management and binding of the processing residues, recycling efficiency, and the positive PR effect from the environmentally sustainable solution. The PR effect in turn relies in the recycling and effective energy utilization of the waste.

7.2.8 Cost Structure

The supplier is not the low cost supplier in the market. Quite the opposite, the supplier emphasizes the quality and the value of the high capacity equipment and machinery it delivers. Thus, the supplier operates clearly on the value driven basis.

The most important sources of costs are the bill of materials, including the outsourced components. The next most important are the salaries and labor costs and logistics cost. The cost of consulting is not considered to match the cost of these previously mentioned components, although that generates a significant portion of the costs as well. The three first mentioned cost components could be attempted to lower by outsourcing some manufacturing and assembly to the local area. This could lower the overall cost, since the energy cost in that area is generally lower than in Finland. Also, the labor costs are lower. The shorter distance could also lower the logistics cost. However, as mentioned before, some manufacturing requires close inspection and extremely skilled labor force and these activities might not be reasonable to outsource to local area. This would only result into an unnecessary risk of, for example, structural failures and in this case the benefits of skilled and trusted manufacturers outweigh the costs.

7.2.9 Revenue Streams

The majority of the revenue the supplier company receives comes from the project delivery and agreed sales contract value. Additional income comes from the aftermarket sales, including service and spare parts sales. The company can also include in their aftersales package services such as adjusting the machinery and lines for optimal performance and to train and educate the process staff to operate the equipment safely and efficiently. Additional documentation can also be provided if the customer wishes to include these to the package.

However, each component is priced separately according to their pricing principles. There are no fixed list prices, since all the deliveries are vastly different. However, the guiding principles for pricing exist and these are utilized. Thus, there is no too advanced or exotic pricing methods and neither is the revenue based on, for example, subscription or capacity sales.

The company can use letter of credit method, whether the situation with the customer requires it or the method seems logical. However, this method might end up being unnecessary on the selected geographical area and only to generate unnecessary costs. Thus, it might be reasonable to not utilize it, unless proven necessary.

8. TEMPLATE NATURE OF THE THESIS

The purpose of this thesis was to support market entry in emerging markets in case of waste utilization in Sultanate of Oman. In general, this means that the main deliverables of this thesis were planned to be tested methods and tools for business model creation for new markets. Thus, for this tool and method creation and testing the case of waste utilization in Sultanate of Oman was selected, as it was a relevant and interesting case for the company for which the thesis project and its deliverables were to be conducted.

The main tools for the future business model generations created in this theses were the feasibility calculation tool and the Weighted Sum Method and ELECTRE III multicriteria decision-making tools. On the other hand, the most important methods for the future business model generations were the use of simulating the customers' behavior and utilizing the Business Model Canvas to illustrate and design the actual business model through the accumulated knowledge from the customer behavior simulation. These two, main tools and methods, are briefly discussed in more depth in following separate chapters. After that, a synthesis over the deliverables and the template nature is discussed.

8.1 Main tools

As mentioned earlier, the main tools for the company created in this thesis are the excel-based feasibility calculation tool and the Weighted Sum Method and ELECTRE III multicriteria decision-making tools, which are also excel based tools. Thus, both of the main tools are concrete numerical calculation tools to be used for aiding future business model generation cases and to provide deeper insight over the situation and possibilities at hand.

The feasibility calculation tool is in essence a profitability calculation tool for various investments. This tool takes into account, for example, the original investment, financing options, discounting factor, and annual cash flows. As an output the tool provides the decision-maker with, for example, net present value, internal rate of return, payback time, various graphs, and option to iterate with values in real time and see the changes immediately.

Another important delivered actual tools were the Weighted Sum Method and ELECTRE III decision-making calculation tools. A multi-criteria decision-making tool called SANNA 2014 was used in this thesis, as it was considered to be reliable and easy to use and thus no reason to create an own version was seen. This tool allows the use of multiple multi-criteria decision-making tools, two of them being the selected Weighted Sum Method and ELECTRE III. On top of Weighted Sum Method and ELECTRE III, the said tool contains various other multi-criteria decision-making tools, but for the purposes of this thesis only the Weighted Sum Method and ELECTRE III were used. Since the amount of alternatives per location was limited and no robust sorting and narrowing of the alternatives was needed, the ELECTRE III tool was used without thresholds, simply ranking the alternatives through straight forward scoring. The tool itself calculated the preference and indifference thresholds according to the provided data to enable sufficient distinction between alternatives.

The SANNA 2014 Excel based multi-criteria decision-making tool, containing the tools for Weighted Sum Method and ELECTRE III tools and other criteria decision-making tools, presented by Jablonsky (2014) in his text turned out to be a great way to simulate the decision making process of the customer. The use of the tool gave deeper understanding about the conclusions the customer might end up to through decision-making and evaluation of the alternatives on the table. This tool might turn out to be extremely valuable to easily and cost efficiently prove some business cases either extremely unfeasible or feasible in the future. However, the use of the tool requires thorough understanding over the customer value, which was discussed in depth in the literature review. The shortcomings of this thesis on this regard is that the input from the customer was only second hand information through the selected professionals' workshop.

8.2 Main methods

The main methods learned and adopted in this thesis regarding the future business model generation cases were the simulation of the customers' behavior and the use of the Business Model Canvas template. Together these processes force the supplier to position themselves to the customers' point of view and thus to gain understanding about the customers' needs and definition of value. This is important starting point for business models and creation of new business, as was discussed in the literature review. The supplier should strive to transform from the product centric view of the market to the value based view, fulfilling the customers' needs according to the capabilities the company has and even try to develop the capabilities according to the identified customer value components.

The simulation of the customers' decision-making was achieved in this thesis through quantitative tools, Weighted Sum Method and ELECTRE III. However, this simulation could be achieved as well by other means. For example, by a business game, where managers from the supplier company play as the managers of the customer company (Laine et al. 2012). Mentioned game concept could force the supplier company managers to view the situation from the customer's point of view and the competitive game nature could help to increase the effort to understand the customer's business and its values. However, the Weighted Sum Method and ELECTRE III methods were the selected tools for this specific case, as those were seen as more suitable tools for current decision-making simulation.

To succeed in the customers' decision-making simulation the supplier has to focus on understanding the customer value. In the used Weighted Sum Method and ELECTRE III methods the value components and their valuation or weights are first identified separately and then included as index numbers into a calculation spreadsheet. The weakness of selected methods is that they do not really take any stand on how the customer value assessment should be concluded. For this reason the literature review part of this thesis handled this subject in some depth. In comparison, the business game concept presented by Laine (2012) enables a very specific and intuitive way to assess customer value as a part of the game and simulation. However, regardless the method, the assessment of customer value is extremely important for the purposes of customer decision-making simulation. Furthermore, when done on a solid base of accurate customer value assessment, the customers' decision-making simulation provides the supplier company with increased understanding over the direction where it should steer its new business model.

The second main method was the use of Business Model Canvas to illustrate and design the actual business model through the accumulated knowledge from the customer behavior simulation. This method positions the customer value proposition into the center role, but also forces the supplier to systematically assess all other relevant components of the business model as well. Thus, the Business Model Canvas could be seen to even function as a check list, so that all important aspects of a business model are surely considered before the business model is finalized. The graphical form and template nature of the Business Model Canvas also enables the supplier to easily and efficiently iterate and compare the different rivaling business models an quickly present the main idea of each business model.

An important factor noted in the use of Business Model Canvas was that the separate segments of the Business Model Canvas can be discussed and considered in varying depth, depending on the situation at hand and what is relevant for the supplier company. For example, in this case, the most important segments were arguably the customer value propositions, cost structures, and revenue streams and these were considered in more depth than other components of the business model canvas. As there were assumed to exist only one customer, be'ah, the customer segments part was handled only briefly.

8.3 Synthesis of the main deliverables and the template nature

The main deliverables were divided into two groups: the main tools and the main methods. The main tools were two Excel template tools, the feasibility calculation tool and the multi-criteria decision-making tool. The first was created in-house for the purposes of this thesis and evaluating the monetary profitability of different investments. The latter, SANNA 2014 Excel tool, was created by a third party and it is presented by Jablonsky (2014) in his text. The SANNA 2014 tool was created for the purposes of making multi-criteria decisions. This tool was found through scientific articles citing to this tool when and it is publicly available on web and works as an excel add-in (Jablonsky 2014).

The main methods are the customers' decision-making simulation and the use of Business Model Canvas to illustrate and design the actual business model through the accumulated knowledge from the customer behavior simulation. The adopted multi-criteria decision-making excel tool was utilized, amongst customer value assessment, to simulate the customer's decision-making. The Business Model Canvas was then utilized in order to create and to present the final business model.

Together the methods and tools enabled to view the situation and supplier's offering from the customer's view point and to compare it to rivaling technologies and the understanding gained from this process was utilized in creation of the business model. The purpose of this thesis was to support market entry in emerging markets in case of waste utilization in Sultanate of Oman. For this purpose the required processes or methods and tools needed to be created and validated. Thus, it was seen that the selected and created tools and methods were successful, fulfilling the set demands.

Another important aspect, which was noted only afterwards, was that the two Excel tools could be also utilized in a consultative manner and during the actual sales process together with the customer. If applied successfully, together these tools could then function as a valuable sales tools, proving the customer the value and justifying the investment. Thus, the delivered tools could turn out to be even more valuable to the supplier company than was initially expected. However, due to the limited timeframe of the thesis project, it was unable to guarantee also the sales force adoption of these tools.

Also, in the literature review it was noted, that by developing the capabilities to identify customer value, the company might also develop a capability to operate in consultative business, bringing the company new business opportunities (Keränen 2014). The use of this tools and bringing them into every day operation might increase these skills in the company, later allowing even the consultative business operations, as described by Keränen (2014). Thus, the adoption of these tools and methods might result, at least in theory, into significant value increase for the company.

9. CONCLUSIONS

In this chapter the conclusions and discussion of this thesis are presented together with summary of achieved results and methodological review. Also, the recommendations for future actions are provided at the end of this chapter.

9.1 Brief summary of the results

The purpose of this thesis is to support market entry in emerging markets in case of waste utilization in Sultanate of Oman. This purpose was formed into one research question and one operative goal. The research question was *"How to take into account the customers' decision-making process in business model generation"*. This research question served the template nature of this thesis, as one objective for this thesis was to function as business model generation template in future for the supplier company. The operative goal was *"What are the proposed technology concepts and investment opportunities for treating waste in Oman"*. The solution to this goal serves the case at hand, providing some answers to the location specific business case.

The initial simplified thesis process illustrated in Figure 1 was further refined into more detailed process. The iterative nature of the customer value identification, scoring of different technology alternatives, and profitability calculations per technology per location were added. This final thesis process is illustrated in Figure 14 below.

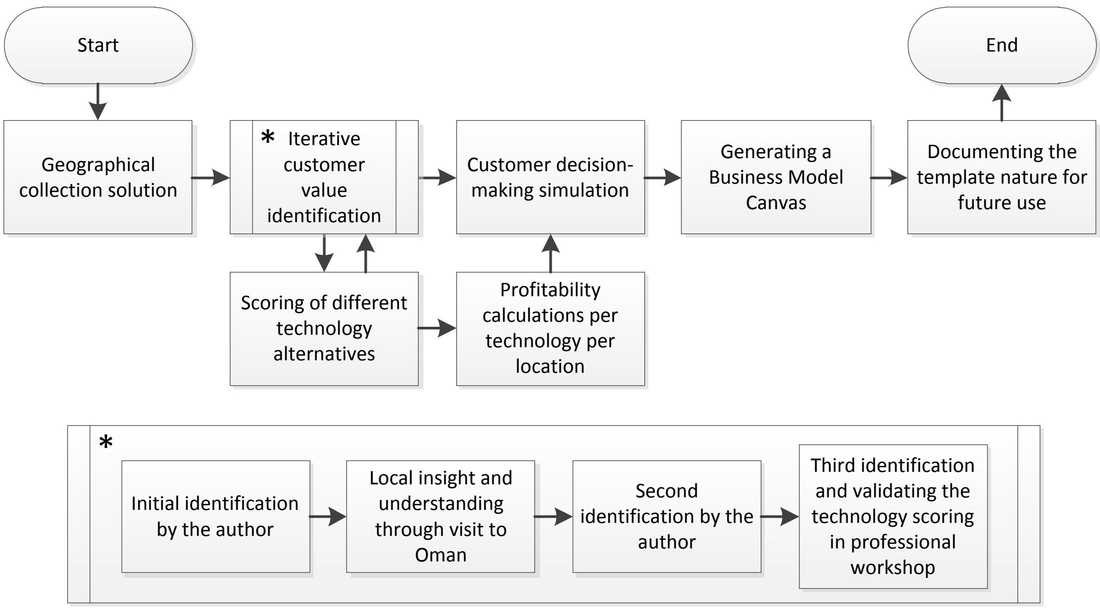

Figure 14. *Final thesis process*

The structure of the thesis was divided into separate segments. First, some background information about the reasons for the thesis was discussed and the Sultanate of Oman was also introduced to the reader through key figures and facts about their waste management. Then the relevant literature was presented and discussed. The literature review focused on customer value and decision-making, as these were chosen to be the most important theoretical frameworks for the future customer value evaluation and the customer decision-making simulation. After literature review the possible technological concepts were introduced to the reader. After this, the actual waste data was analyzed and different collection clusters were created. The data from the collection clusters was utilized in financial calculations. In the same part of the text, the decision-making simulation is executed. The results from the decision-making simulation are then used to create the Business Model Canvas for the selected market area. Lastly, the template nature of this thesis is discussed before the conclusions.

Five collection clusters were created. The main driver for generating the collection cluster areas was that the driving time should not exceed two hours to the center of the cluster. Later it was noted, that this requirement correlated well with 100 kilometer radius. Thus, this 100 kilometers was used to simplify the generation. There was only one collection location included in the parent collection cluster that exceeded the two hours driving time. However, as it exceeded this threshold only by 10 minutes, it was decided that it will be included. The created five collection clusters form three larger clusters, Salalah, Muscat, and Sohar-Yanqul and two smaller clusters, Al Kamil and Adam. The overall collection efficiency is very high and the selected clusters catch over 98% of all the waste produced in Oman.

For the customer decision-making simulation two separate quantitative tools were used. The input data for both tools was similar and both of them were MS Excel based. 17 criteria were identified and weighted according to the identified customer value components. 7 technology concept alternatives were included in decision-making for the three largest locations. The two smaller locations received only two technology concept alternatives due to the insufficient waste amount to consider waste incineration. Location specific simulations were performed by Weighted Sum Method and ELECTRE III method and results were listed and compared. For the three largest collection clusters the main result was clearly in the favor of technology alternative 2, the other top four technologies consisting from technology alternative 1, technology alternative 3, and technology alternative 4, in varying order in each location. For the two smaller collection clusters the result was in both cases favorable for the technology alternative 5. However, this concept relied heavily on the assumption that the technology alternative 5 could be downscaled enough. In case this is not possible in economically feasible manner, the technology alternative 7 would be the most feasible solution.

Due to the increased understanding about the customers’ viewpoint, the generated Business Model Canvas relied heavily on technology alternative 2. This meant that some of the main components in the value proposition were derived from the viewpoint of the technology alternative 2.

9.2 Methodological review

The template nature objective is satisfied by providing the concrete tools and methods to generate reliable business models in future. The tools this thesis provides are a tool for generating the economical profitability calculations and a tool for performing the quantitative customer value simulation. Both of these tools are MS Excel based and thus easy to use and to perform even what-if analyses. The main methods this thesis provides are the use of customers' decision-making simulation and the use of Business Model Canvas to draft, illustrate, create, and to present the finalized business model. The simulation forces the supplier to analyze the customer perceived value and to set rivaling technology concept alternatives on the same starting point. Analytical and neutral analysis guarantees reliable simulation results, which can further be utilized in business model creation. Thus, it is extremely important to objectively assess the customer value components, their weights and the performance of each alternative per criteria or value component.

The methods and tools explained in the Template nature chapter of this thesis answers to the research question. In order to receive reliable results from the simulation, the process forces the supplier company to assess the customer value components, their weights and then objectively assess the performance of each alternative per criteria or value component. Thus, this process takes into account the customer's decision-making process.

The value components and their weights can be identified by several methods. These methods are discussed in the literature review in more depth, but the supplier can, for example, organize a workshop with the customer's representatives or simply conduct interviews. In this case, an iterative process of three steps was used due to the project reason restrictions out of the scope of this thesis. At the first stage the identification was exclusively conducted by the author relying on public and shared internal material. At the second stage this identification was refined with the additional understanding and knowledge gained during a visit to the actual location and discussing with the local stakeholders. The third iteration further refined this identification in a professional workshop. The workshop was arranged so that representatives from supplier company, consulting company, and university could participate. After the third iteration the data was considered to be reliable enough for the simulation purposes.

The benefits of this iterative three phase process were numerous. The process was very efficient in terms of resources, as only the author was used as an active human resource in the first two stages. The first stage was also very cost efficient, as the only costs generated from the hourly costs of the author and no materials or services needed to be purchased. The second stage included the cost of the visit to Oman. However, as the main purpose for the visit was project related, the benefits for the thesis project were, more or less, generated as a side product for the true project related actions. Also, while not conducting the actual interviews the author was placed into the position of invisible spectator in terms of the objectives for the thesis purpose. Thus the research process in Oman resembled a case study, where the researcher participates but has a hidden agenda. This gives the researcher a different kind of access that they might not receive by conducting normal interviews and formally publishing their research agenda and objectives. This was noted in the identification of the weights of some of the customer value components, as the author gained access to even some information that would probably have been left unmentioned or unnoticed in an interview setting. An example of this was the importance of compactness and location related questions. This subject rose to discussion many times and provoked multiple questions. Mainly the concerns were related with the future land usage, expansion reserve for the industry and the odor factors. Also, the fact that the initial investment was not as big as a concern as was expected, was indicated subtly. The technical level of newly established industrial references that were observed either directly or indirectly during the visit also proved, that the technical complexity is not going to be as critical issue as was initially assessed, even though this matter was never spoken about directly. Thus it can be said, that this kind of unspoken information played a great role when reassessing the weights at the second phase and in this regard the method proved successful.

The third phase was based on the two previous phases and in the beginning of the workshop a short presentation about the first two phases was held by the author. Thus, the professionals attending to the workshop were burdened as lightly as possible before the workshop, saving resources, and then brought up to date with the current situation in an effective manner via prepared presentation, enabling the workshop to be efficient in identifying the values and their weights.

Despite the numerous advantages of this selected three stage iterative method to identify the customer value components and their weights, it also has some shortcomings. The documentation of the process could have been more precise, especially the first and second phases. The second phase was documented in a normal travel memo and the first stage was only documented in the author’s own memo, when the formal interviews would have generated actual discussion recordings and then memos based on those recordings. Also, interviews or questionnaires could have given an access to direct customer input, which now was absent. This could have had some value and might have revealed some factors that now were left unnoticed. Also, the other resources than the author were employed as lightly as possible, mainly focusing their input to the professional workshop. This method undoubtedly saved costs, however, including several opinions in the first and second stage could have also had an impact on results.

All in all, the method was assessed to provide reliable enough results for the decision making simulation. The remaining uncertainty was considered to be acceptable, as the whole subject was, in general, very abstract. Also, all of the simulation results proved to be quite effectively in line with only a small variance in results. Thus, it was considered, that the likely small scale imprecision in decision-making simulation input data due to the lack of customer input and abstract nature of the subject would not cause significant changes that would result into completely different business models. This assumption was also based on the fact that the business model is generated on existing business that the supplier company has and the SRF based technologies are all quite similar in delivery scope for the supplier company. This is even though there is some small differences between the technology alternative 2 and technology alternatives 1, 3, 4, and 5. However, the additional equipment needed to achieve the required for the technology alternative 2 generates a very small fraction of the total average project scope. Also, as the technology alternative 7 and technology alternative 6 technologies were in all cases clearly inferior, it was assumed that the simulation results are reliable and that the method is not too sensible to changes in input data caused by the imprecision of the selected identification method.

The largest difference between the results of Weighted Sum Method and ELECTRE III method was in Sohar-Yanqul location. In this location the ELECTRE III method gave technology alternative 1 the highest points, whereas the Weighted Sum Method placed it to the fourth place. Also in Muscat area the results for the top two, consisting of technology alternative 2 and technology alternative 3 alternatives in both cases, was reversed between the simulation methods. These highlights in differences of the simulation methods are undoubtedly interesting, as the results of both methods were mainly in line with each other. However, if the other should be chosen, the Weighted Sum Method would seem more accurate in this case, according to feedback from actual cases. Also, the use of Weighted Sum Method is simpler and it is easier for the decision-maker to understand how the result is achieved. However, the use of both tools simultaneously could also increase the reliability of the results, when the results are more or less in line with each other as was mainly the case in this scenario.

The Business Model Canvas and simulation results answers to the operative goal set to the thesis. The proposed technology concepts for the three largest collection clusters are mainly focused around the technology alternative 2, however the other top four technologies could also be considered. This depends heavily about the demand for side products and if deeper insight about this parameter could be gained and thus the results would change, then the recommendations for the other top four technology alternatives might change as well. For the two smaller collection clusters, Al Kamil and Adam, the initial recommendation is the technology alternative 5. However, this contains heavy uncertainty, as the ability to downscale the technology alternative 5 sufficiently is unknown.

9.3 Discussion

The contribution to existing literature is quite limited in this thesis, as the thesis project was mainly oriented to find a solution for the supplier company’s existing problem, using methods, frameworks and theory already known. Thus, the main contribution to literature is, more or less, applying this kind of iterative value identification process and combining it with the quantitative multi-criteria decision-making tools to simulate customers' decision-making to gain insight for the business model generation. The method gave promising results in terms of feedback from the actual projects and sales leads. Also, the method proved out to be quite cost efficient. It might also be possible to undergo a similar process in future in quite a rapid phase, as the process is now well documented and all the forms and templates are ready for future use. However, it can be expressed that the text did not contribute to the existing literature with new theoretical input, as no new theoretical frameworks or propositions were made. This text was, more or less, an application case of customer value identification and quantitative multi-criteria decision-making tools. Thus, answering the research question by utilizing the three step iterative customer value identification process, customer decision-making simulation and providing a Business Model Canvas provides an application example of these tools with analyzed advantages and disadvantages in this case. The application case and its connection to existing literature is further discussed in this chapter.

In their text Kothari & Lackner (2006) argue that companies should view the market within the company from outside in. In essence, this would help the company to focus on developing their operation to answer customer needs by developing value components that customers currently value and thus to shift away from product-centric viewpoint. This is important, as the value components the customers value might be changed from the initial value components with which the company begun its operation. Keränen & Jalkala (2013a) also address this matter in their text by arguing that the customer value identification should be continuous process and occur before, during, and even long after the delivery is done to the customer.

In this text the market was, indeed, attempted to view from outside in and thus to objectively identify the value components the customers currently might value. This would then help the supplier company to select geographical locations where their offering's value components will have positive demand. However, the suggestion of continuous customer value identification suggested by Keränen & Jalkala (2013a) was not adopted into this thesis due to the timeframe limitations. On the other hand it was also noted that the discrete value identification executed now during the thesis project will most probably provide sufficient reliability for some near future as well. This was due to the fact that the energy- and waste industries are mainly affected by political decision making, investments are made for decades, and in general these industries are very slow in terms of change. This is especially if compared to, for example, information technology industry. Thus, it was not seen important to utilize continuous value identification as suggested by Keränen & Jalkala (2013a) and to include it into the recommended future actions, as it increases the complexity and therefore the marginal benefits are outweighed by the costs.

Anderson & Narus (1998) suggest two methods for customer value identification and assessment. These methods are customer focus groups and field assessment (Anderson & Narus 1998). The first method, customer focus groups, was not directly seen as possible alternative component in the concluded iterative three step customer value identification process. This was due to the reason that interviews and all other direct involvement of customer was not allowed due to project reasons of the supplier company. However, the second proposed method, the field value assessment was included as one step of the three step iterative process. In their text, Anderson & Narus (1998) suggest creating a value assessment team of various professionals. However, in this thesis project the value assessment team consisted only of the author and an Eera consulting company representative, who was also present in the final step, the professional workshop. It was decided, that considering the resources available and the deliverables generated during the field value assessment, the generated value assessment team was sufficient. Thus, even though it might not always be possible to form an ideal value assessment team including representatives from sales, product management, and marketing, as suggested by Anderson & Narus (1998), in some cases important results can also be achieved with a smaller value assessment team. Also, the documentation of the observations was seen as very important factor of the value assessment on the field, as the assessment can last for quite some time. In this case a diary type travel memo relying on chronologically organized bullet points was seen as sufficient method. Also, the very low level of order made it easy and encouraging to write down even the smallest observations, thus enabling comprehensive documentation in chronological order.

As mentioned before, the customer focus groups method was not directly seen as suitable. However, elements of it were utilized in the third step of the three step iterative customer value identification process. In this third step a professional workshop was held, based on the results from the two previous customer value identification steps. Thus, it could be called, for example, professional focus group. However, this group had only one workshop meeting as opposed to several focus group meetings suggested by Anderson & Narus (1998). As this was not ideal, some results were still gained with lesser costs and utilization of resources, of which the time of the several professionals was undoubtedly the scarcest. Thus, even this kind of adaption of the customer focus groups method could provide sufficient results, when customers are ruled out from the customer value identification and when the time resources of the decision-makers are very limited.

In this text the customer value identification and analysis was executed in an iterative three phased method. The components in this iterative method were initial identification by the author, adapted field value assessment, and professional workshop with elements from customer focus groups method. Conducting the customer value assessment in three iterative steps proved out to be both cost efficient and reliable method. Also, the components of which methods each separate step is consisted of can be varied according to any specific case in question. This will ensure, that the method can be selected in a way that the execution of the value assessment and identification is feasible in the first place, and secondly, in a way that it provides reliable results. Thus these methods can be, for example, direct interviews, questionnaires, methods suggested by Anderson & Narus (1998), or any other method that in future is considered feasible.

The customer's decision-making was simulated in this text by utilizing quantitative decision-making tools. These tools were Weighted Sum Method and ELECTRE III and those were used in an MS Excel tool called SANNA 2014 presented in his text by Jablonsky (2014). The method proved out to be extremely cost efficient and easy to use, as no auxiliary software needed to be installed and, in general, the MS Excel user interface is familiar to most of the decision-makers. On the other hand, some other decision-making simulation tools could be used in future as well to provide estimates about the customers' probable decisions and to enforce the customer value assessment. For example, the business game concept presented by Laine (2012) could be one alternative. This alternative would also, at least in some depth, contain customer value identification and assessment functions internally, as that is a side product of the game when managers position themselves to the customers' managers' point of view. Thus, this method could be a great way to combine customer value identification and assessment together with customer decision-making simulation and to simultaneously receive many different outcomes, as multiple teams would participate into the game. In addition, the game would most likely increase the overall understanding of customers' business within the company's managers, thus laying foundations for future actions to take customer and their value components better into account in everyday business. On the other hand, this method was not initially included into this thesis as a part of this iterative three step method. This is because when compared to the three selected methods, the business game method might end up being too resource intensive since the time of the professionals was one extremely scarce and thus limiting resource. However, as the methods should be selected case by case, the business game method might end up being feasible in some cases.

The amount of iterations in customer value identifying and assessment can vary also. In this specific case three iterations seemed to give reliable results with reasonable costs. In some other cases the amount iterations can be less or more. Also the selected methods might influence the amount of iterations. For example, if the business game method is utilized, the amount of iterations could be only two. The first iteration could be thorough utilization of customer focus group method and aim to create as realistic business game about customers' businesses as possible. The second iteration could then be the business game played by the supplier company's managers. This iteration would also simulate the customers' actions and decision-making. Thus, the simulation results and refined understanding about customer value would be achieved in the same phase. Also, the results might be easier to understand to the managers, as they have been participating in creating those results by playing the business game themselves. This might, however, not always be the case when utilizing the quantitative decision-making tools, such as Weighted Sum

Method or ELECTRE III, as the derivation of the results might not be easy to understand even though the result itself might be as user friendly as, for example, listed order of favorability of different alternatives.

In this case the use of Business Model Canvas was specified by the supplier company, as the output business model was wanted in the form of Business Model Canvas. However, the Business Model Canvas appeared to also fit well this case as most of the critique addressed in literature review chapter and presented by Kraaijenbrink (2012) can be mitigated by taking into account the business the supplier company is currently operating on. On the other hand, even though the Business Model Canvas enables an efficient tool to illustrate new business models and to present them intuitively, some other methods might be utilized as well, if seen necessary. However, currently the Business Model Canvas seems feasible solution, even if some components of the Business Model Canvas might not contain new or groundbreaking information for the company, as the business model is generated on the basis of existing business the company has. Because of this, it could seem rational to simplify the Business Model Canvas tool by creating default fields to, for example, Key Partners, Key Activities, Key Resources and Customer Segments. However, this would probably result into a state where these components would always be left for the default state and thus those would never be re-assessed during business model generation. For this reason, it would probably be reasonable to maintain the Business Model Canvas tool as Osterwalder (2010) presented it and to force the decision-maker to recreate the whole business model each time.

9.4 Recommendations for action

By providing the clear answers to the set research question, operative goal, and providing concrete tools and methods for future business model generation, the thesis fulfills its purpose. The thesis supports market entry in emerging markets and this is achieved through generating methods and tools for the business model generation by utilizing the case of waste utilization in Sultanate of Oman. Some future development regarding this method and tools might be necessary, even though the method and tools already provide quite efficient template to generate future business models. These future development subjects are discussed more in detail below.

The now identified 17 criteria could be further refined to make the criteria hierarchy more clear and to ensure that every aspect of the decision-making situation is identified and weighted. For example, now there are four main categories. These are Financial, Ecological, Social and Utility. This division could be changed to, for example, directly according to PESTEL model. Also, the main 17 criteria should be checked and if necessary, add or remove some criteria and locate them correctly under PESTEL main categories. After this, the main criteria could even be further divided into sub criteria, so that each main criteria would consist of several sub criteria.

The legal factors of the PESTEL model should be also included. The legal factors were not seen as too important in this specific case, as the initiative was made by the government itself and the customer was owned by the government. However, to enable the future use, the legal consideration should be included, as the future customers might not always be working directly under government's order.

Another possible future development area could be the calculation and decision-making tools. The tools could be made simpler to use and the documentation and written guides could be developed further. Now some guides and documentation exist, but they are still more or less on a draft stage. There is also potential for future version releases for multi-criteria decision-making tools and these, when released, should also be analyzed and if proven useful, included in the tool collection.

One important development area would be to study the ability to scale down the technology alternative 5. At the moment the proposed solution for the Al Kamil and Adam rely heavily on the ability to scale down the technology alternative 5 in an economically feasible manner. As this might not be the case in reality and was just assumed for the purposes of this study, this needs still some further research.

To enable more accurate results, the local stakeholders' opinions should be included in the study through some direct method. This could be achieved through, for example, various workshops with different stakeholder representatives from each collection cluster area or through several interviews and questionnaires. Especially the demand for side products and the overall relation between the weights of the financial, ecological, social and utility criteria. This direct contact was not allowed during this thesis process, but at the later stage, if the option arises, it could and should be performed.

For the company the recommendations for the future are considering the generated Business Model Canvas and focusing on the three largest collection clusters. Also the adoption of this business model generation template that this thesis represents, and all the generated tools and methods should be adopted into normal use. To get reliable data for the future business model generation cases the company should especially focus on mastering the choosing of the necessary iteration amounts and the selection of methods for iterations as that is case specific and this thesis does not give a straight answers to that problem.

BIBLIOGRAPHY

Anderson, J.C. & Narus, J.A. (1998). Business marketing: understand what customers value. Harvard business review, Vol. 76(6), pp. 53-55.

Anderson, J.C., Narus, J.A. & Van Rossum, W. (2006). Customer value propositions in business markets, Harvard business review, Vol. 84(3), pp. 91-99.

Barberis, N.C. (2013). Thirty years of prospect theory in economics: A review and assessment, Journal of Economic Perspectives, Vol. 27(1), pp. 173-196.

be'ah (2013). Waste characterization and quantification - Final municipal waste survey, be'ah, Oman, 1-85 p.

be'ah. About Us, be'ah, web page. Available (accessed 10.8.2015): http://www.beah.om/about_us.php.

BMH (2014). BMH Technology Oy - Comprehensive Waste to Energy Concepts, Rauma, BMH, Company internal source, 1-18 p.

Brunner, C. (2002). Waste-to-energy combustion part 13A Incineration technologies, in: Tchobanoglous, G. & Kreith, F. (ed.), Handbook of solid waste management, 2nd ed., McGraw-Hill, New York, pp. 13.3-13.84.

CIA. Oman, Central Intelligence Agency, web page. Available (accessed 29.7.2015): https://www.cia.gov/library/publications/the-world-factbook/geos/mu.html.

Convaero. Bio-Dry-Technology, CONVAERO GmbH, web page. Available (accessed 4.8.2015): http://www.convaero.com/Technology/Bio-Dry-Technology.html.

Diaz, L., Savage, G. & Golueke, C. (2002). Composting of municipal waste, in: Tchobanoglous, G. & Kreith, F. (ed.), Handbook of solid waste management, 2nd ed., McGraw-Hill, New York, pp. 12.1-12.70.

EHC. Tariffs, Welcome to Electricity Holding Company S.A.O.C, web page. Available (accessed 31.8.2015): http://www.electricity.com.om/tabid/170/Default.aspx.

European Recovered Fuel Organisation. INFORMATION DOCUMENT ON EN15359 “Solid Recovered Fuels – SPECIFICATIONS AND CLASSES”, web page. Available (accessed 6.8.2015): http://erfo.info/fileadmin/user_upload/erfo/documents/reports/Information_document_EN15359.pdf.

Figueira, J., Mousseau, V. & Roy, B. (2005). ELECTRE methods, in: Figueira, J., Greco, S. & Ehrgott, M. (ed.), Multiple Criteria Decision Analysis : State of the Art Surveys, 1st ed., Springer Verlag, Boston, Dordrecht, London, pp. 133-162.

FMEA. About, The Finnish Material Efficiency Alliance, web page. Available (accessed 4.8.2015): http://www.fmea.fi/.

Harvard. The Atlas of Economic complexity, Center for International Development: Harvard University, web page. Available (accessed 29.7.2015): http://atlas.cid.harvard.edu/explore/tree_map/export/omn/all/show/2013/.

Hasselriis, F. (2002). Waste-to-energy combustion part 13B Ash management and disposal, in: Tchobanoglous, G. & Kreith, F. (ed.), Handbook of solid waste management, 2nd ed., McGraw-Hill, New York, pp. 13.85-14.1.

Helen Oy. Tuotteet ja palvelut, Helen Oy, web page. Available (accessed 21.9.2015): https://www.helen.fi/kotitalouksille/.

Hinterhuber, A. (2008). Customer value-based pricing strategies: Why companies resist, Journal of Business Strategy, Vol. 29(4), pp. 41-50.

Hinterhuber, A. (2004). Towards value-based pricing - An integrative framework for decision making, Industrial Marketing Management, Vol. 33(8), pp. 765-778.

Hokkanen, J. & Salminen, P. (1997). Choosing a solid waste management system using multicriteria decision analysis, European Journal of Operational Research, Vol. 98(1), pp. 19-36.

Jablonsky, J. (2014). MS Excel based Software Support Tools for Decision Problems with Multiple Criteria, Procedia Economics and Finance, Vol. 12(-), pp. 251-258.

Jalkala, A. & Keränen, J. (2014). Brand positioning strategies for industrial firms providing customer solutions, Journal of Business & Industrial Marketing, Vol. 29(3), pp. 253-264.

Kahneman, D. (2003). A Perspective on Judgment and Choice: Mapping Bounded Rationality, American Psychologist, Vol. 58(9), pp. 697-720.

Kahneman, D. & Tversky, A. (1979). Prospect Theory: An Analysis of Decision under Risk, Econometrica, Vol. 47(2), pp. 263-292.

Karagiannidis, A. & Moussiopoulos, N. (1997). Application of ELECTRE III for the integrated management of municipal solid wastes in the greater Athens area, European Journal of Operational Research, Vol. 97(3), pp. 439-449.

Keränen, J. (2014). Customer value assessment in business markets, Thesis for the degree of Doctor of Science, Acta Universitatis Lappeenrantaensis 579, 1-83 p. Available: http://www.doria.fi/bitstream/handle/10024/97024/ker%C3%A4nen%20A4%20%205%206%20%20pdf%20FINAL.pdf?sequence=2.

Keränen, J. & Jalkala, A. (2013a). Towards a framework of customer value assessment in B2B markets: An exploratory study, Industrial Marketing Management, Vol. 42(8), pp. 1307-1317.

Keränen, J. & Jalkala, A. (2013b). The process of customer value assessment in B2B markets: Insights from best practices, Proceedings of the IMP 2013, 29th Industrial Marketing and Purchasing Conference, 7/2013, IMP, Atlanta, USA, pp. 24.

Kim, B., Kim, S. & Sahoo, S. (2006). Waste collection vehicle routing problem with time windows, Computers & Operations Research, Vol. 33(12), pp. 3624-3642.

Kothari, A. & Lackner, J. (2006). A value based approach to management, Journal of Business and Industrial Marketing, Vol. 21(4), pp. 243-249.

Kraaijenbrink, J. Three shortcomings of the business model canvas, web page. Available (accessed 7.12.2015): http://kraaijenbrink.com/2012/07/shortcomings-of-the-business-model-canvas/.

Laine, T., Paranko, J. & Suomala, P. (2012). Using a business game concept to enhance servitization: a longitudinal case study, Managing Service Quality: An International Journal, Vol. 22(5), pp. 428-446.

Levy, J.S. (1997). Prospect Theory, Rational Choice, and International Relations, International Studies Quarterly, Vol. 41(1), pp. 87-112.

Nuortio, T., Kytöjoki, J., Niska, H. & Bräysy, O. (2006). Improved route planning and scheduling of waste collection and transport, Expert Systems with Applications, Vol. 30(2), pp. 223-232.

O'Leary, P. & Tchobanoglous, G. (2002). Landfilling, in: Tchobanoglous, G. & Kreith, F. (ed.), Handbook of solid waste management, 2nd ed., McGraw-Hill, New York, pp. 14.1-15.1.

Osterwalder, A., Pigneur, Y. & Clark, T. (2010). Business model generation: A Handbook for Visionaries, Game Changers, and Challengers, 1st ed., John Wiley & Sons, Inc., Hoboken, New Jersey, 281 p.

Pohekar, S.D. & Ramachandran, M. (2004). Application of multi-criteria decision making to sustainable energy planning - A review, Renewable and Sustainable Energy Reviews, Vol. 8(4), pp. 365-381.

Professional Academy. MARKETING THEORIES – PESTEL ANALYSIS, Professional Academy, web page. Available (accessed 28.9.2015): http://www.professionalacademy.com/blogs-and-advice/marketing-theories---pestel-analysis.

Rand, T., Haukohl, J. & Marxen, U. (2000). Municipal Solid Waste Incineration - A Decision Maker's Guide, The International Bank for Reconstruction and Development / The World Bank, pp. 1-25.

Said, A. (2014). Waste Management in Oman, Oman Environmental Services Holding Co., Presentation for 3rd International Conference for Waste Management Oman 2014, 1-23 p.

Salem Khalifa, A. (2004). Customer value: a review of recent literature and an integrative configuration, Management Decision, Vol. 42(5), pp. 645-666.

Shipley, D. & Jobber, D. (2001). Integrative Pricing via the Pricing Wheel, Industrial Marketing Management, Vol. 30(3), pp. 301-314.

Spath, P. & Dayton, D. (2003). Preliminary Screening — Technical and Economic Assessment of Synthesis Gas to Fuels and Chemicals with Emphasis on the Potential for Biomass-Derived Syngas, NREL/TP-510-34929, National Renewable Energy Laboratory, Battelle, 1-160 p. Available: http://www.fischer-tropsch.org/DOE/DOE_reports/510/510-34929/510-34929.pdf.

Strategyzer. The Business Model Canvas, Strategyzer, web page. Available (accessed 4.8.2015): http://businessmodelgeneration.com/canvas/bmc.

Solid recovered fuels. Specifications and classes (2012). SFS-EN 15359.

Tampereen Sähkölaitos Oy. Kaukojäähdytys, Tampereen Sähkölaitos Oy, web page. Available (accessed 21.9.2015): https://www.tampereensahkolaitos.fi/kaukolampojaahdytysjamaakaasu/kaukojaahdytys/Sivut/default.aspx.

Taniguchi, E., Noritake, M., Yamada, T. & Izumitani, T. (1999). Optimal size and location planning of public logistics terminals, Transportation Research Part E: Logistics and Transportation Review, Vol. 35(3), pp. 207-222.

Tarik, N. (2014). Waste Disposal Infrastructure In Oman - Landfill Design & Construction Standards, Oman Environmental Services Holding Co., Presentation for 3rd International Conference for Waste Management Oman 2014, 1-61 p.

Tatsiopoulos, I.P. & Tolis, A.J. (2003). Economic aspects of the cotton-stalk biomass logistics and comparison of supply chain methods, Biomass and Bioenergy, Vol. 24(3), pp. 199-214.

Töytäri, P., Alejandro, T.B., Parvinen, P., Ollila, I. & Rosendahl, N. (2011). Bridging the theory to application gap in value-based selling, Journal of Business and Industrial Marketing, Vol. 26(7), pp. 493-502.

Töytäri, P. & Rajala, R. (2015). Value-based selling: An organizational capability perspective, Industrial Marketing Management, Vol. 45(1), pp. 101-112.

Töytäri, P., Rajala, R. & Alejandro, T.B. (2015). Organizational and institutional barriers to value-based pricing in industrial relationships, Industrial Marketing Management, Vol. 47pp. 53-64.

Turku Energia. Kaukolämpöhinnasto, Turku Energia, web page. Available (accessed 28.8.2015): http://www.turkuenergia.fi/yrityksille/lampo/kaukolampohinnastot/.

Tversky, A. & Kahneman, D. (1992). Advances in prospect theory: Cumulative representation of uncertainty, Journal of Risk and Uncertainty, Vol. 5(4), pp. 297-323.

Tversky, A. & Kahneman, D. (1974). Judgment under uncertainty: heuristics and biases. Biases in judgments reveal some heuristics of thinking under uncertainty, Science, Vol. 185(4157), pp. 1124-1131.

U.S. Environmental Protection Agency. An Overview of Landfill Gas Energy in the United States, U.S. Environmental Protection Agency, web page. Available (accessed 28.8.2015): http://www.epa.gov/lmop/documents/pdfs/overview.pdf.

Vego, G., Kucar-Dragicevic, S. & Koprivanac, N. (2008). Application of multi-criteria decision-making on strategic municipal solid waste management in Dalmatia, Croatia, Waste Management, Vol. 28(11), pp. 2192-2201.

Waste Framework Directive (2008). 2008/98/EC. Available: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32008L0098&from=EN.

Wouters, M. & Kirchberger, M.A. (2015). Customer value propositions as interorganizational management accounting to support customer collaboration, Industrial Marketing Management, Vol. 46(-), pp. 54-67.

Appendix 1 Collection location data

Governorate	Wilayat	lat	long	Name that was used if different from given	Other source than Google maps if used
Muscat	Mutrah	23.617528	58.557277		
	Muscat	23.589009	58.404097		
	Bawshar (to Al Multaqa Landfill)	23.565486	58.420039		
	Bawshar (to Barka dumpsite by private trucks)	23.565486	58.420039		
	As Seeb (to Al Multaqa Landfill)	23.627395	58.166315	Seeb	
	As Seeb (to Barka dumpsite)	23.627395	58.166315	Seeb	
	Al Amrat	23.589180	58.525444		
	Qurayyat	23.265427	58.903338		
	Governorate level ***	23.589009	58.404097	Muscat	
Al Batinah North	Sohar	24.346290	56.707492		
	As Suwayq	23.826286	57.428694	Al Suwayq	
	Saham	24.153819	56.864076		
	Shinas	24.724679	56.460622		
	Al Khabura	23.982581	57.099598	Al Khaburah	
	Liwa	24.506191	56.594855		
Al Batinah South	Barka	23.683638	57.904760		
	Al Musanaah	23.783255	57.633160	Al Masnaah	
	Rustaq	23.390755	57.424412		
	Wadi Al Maawal	23.792880	57.509045	Al Mudayq	http://www.viamichelin.com/web/Maps/Map-Wadi_Al_Maawil-_-Al_Batinah-Oman?strLocid=31NTFiYTg4MTBjTWpNdU56azJNVEU9Y05UY3VORGs0TWpJPQ==
	Nakhal	23.394518	57.819462		
	Al Awabi	23.307934	57.536173		
Adh Dhahirah	Ibri	23.235262	56.494618		
	Yanqul	23.598510	56.544490		
	Dank	23.545081	56.259634		
Ad Dakhliyah	Nizwa	22.918030	57.535633		
	Bahla	22.951084	57.293149	Bahlat	
	Sumail – not surveyed	23.297326	57.972734		
	Al Hamra	23.102652	57.287395		
	Izki	22.933762	57.774820		
	Bid Bid	23.406973	58.124177	Bidbid	
	Adam – not surveyed	22.386664	57.524972		
	Manah – not surveyed	22.793186	57.592631		
Ash Sharqiyah South	Sur	22.565675	59.506075		
	Jalan Bani Bu Ali	22.019187	59.345140		
	Jalan Bani Bu Hassan	22.090365	59.276432	Jalan Bani BuHassan	
	Al Kamil Wa Al Wafi	22.209625	59.213251	Al Kamil Wal Wafi	
	Masirah – not surveyed	20.320047	58.689538		
Ash Sharqiyah North	Al Mudaybi	22.573081	58.126682	Al Mudaybi المضيبي	
	Ibra	22.724345	58.525559		
	Bidiyah	22.442710	58.800104		
	Al Qabil	22.567994	58.684842	Al Qabil القابل	
	Dama Wa At Taiyyin – not surveyed	23.051142	58.599590	Dima W'attayeen	
	Wadi Bani Khalid – not surveyed	22.599754	59.086833		
Al Wusta	Mahawat – only surveyed in season 1	20.617441	58.193604	Filim	http://www.arcgis.com/home/webmap/viewer.html?webmap=cd33b9c4b4da4647b240d0733c69d2a3
	Duqum	19.639686	57.677767		
	Hayma – only surveyed in season 2	19.953357	56.287356	Haima	
	Al Jazer – Not surveyed	18.229052	56.554460	Lakabi	
Dhofar	Salalah	17.017470	54.088393		
	Thumrayt	17.634752	54.033199	Thumrait	
	Taqah	17.054804	54.379350		
	Mirbat – Not surveyed	16.988705	54.692613		
	Sadah – Not surveyed	17.056062	55.067403		
	Rakhyut – Not surveyed	16.783038	53.299754	Jabal Rakhyut	
	Dalkut – Not surveyed	16.706102	53.187462		
	Muqshin – Not surveyed	18.850286	54.207113	Desert!!	
	Shalim Wa Juzur Al Hallaniyat – Not surveyed	18.102271	55.651824	Shalim Wa Juzor Al Hallaniyyat	
	Al Mazyunah – Not surveyed	17.839872	52.657394		
Al Buraymi	Al Buraimi	24.262720	55.771115	Industrial Area Al Buraimi	
	Mahadah – Not surveyed	24.406965	55.963914	Mahdah	
	As Sinainah – Not syrveyed	23.618593	55.956091	As Sunainah	
Musandam	Khasab – only surveyed in season 2	26.181888	56.248942		
	Bukha – Not surveyed	26.140787	56.153265		
	Dibba – Not surveyed	25.636440	56.253717		
	Mudha –Not surveyed	25.284716	56.333063	Madha	

be'ah (2013). Waste characterization and quantification - Final municipal waste survey, be'ah, Oman, 1-85 p.

Appendix 2 Collection location waste amounts

Wilayat	Park & Garden Waste	Municipal Waste	Slaughter	Industrial waste	Total
Mutrah	2320	66 610	0	39448	108 378
Bawshar	523	78 068	8	3629	82 228
As Seeb	40248	103 571	0	12432	156 252
Al Amrat	0	22 345	0	0	22 345
Qurayyat	0	10 703	0	0	10 703
Sohar	11 521	40 691	363	13 174	65 749
As Suwayq	4 532	36 377	16	0	40 925
Saham	3 960	28 519	0	357	32 837
Shinas	0	13 203	0	0	13 203
Al Khabura	3 298	13 047	0	0	16 345
Liwa	1 682	7 564	0	1 642	10 889
Barka	2 937	40 770	566	2 694	46 968
Al Musanaah	1 137	12 715	0	0	13 851
Rustaq	135	18 407	0	0	18 543
Wadi Al Maawal	0	2 221	23	34	2 278
Nakhal	51	2 565	0	0	2 616
Al Awabi	0	5 012	0	0	5 012
Ibri	63	15 127	63	455	15 708
Yanqul	0	4 028	0	0	4 028
Dank	0	2 660	0	0	2 660
Nizwa	2 590	18 522	34	689	21 836
Bahla	0	7 566	40	0	7 606
Sumail	1 027	10 272	29	273	11 602
Al Hamra	0	4 761	0	0	4 761
Izki	183	6 870	0	0	7 053
Bid Bid	153	7 112	0	172	7 437
Adam	107	5 977	0	55	6 138
Manah	59	3 294	0	30	3 383
Sur	1 001	13 165	0	953	15 119
Jalan Bani Bu Ali	491	19 429	40	102	20 062
Jalan Bani Bu Hassan	0	5 020	0	0	5 020
Al Kamil Wa Al Wafi	5 126	3 493	0	0	8 619
Masirah	835	1 406	0	0	2 241
Al Mudaybi	0	5 277	0	0	5 277
Ibra	108	6 222	0	0	6 330
Bidiyah	4 315	9 859	0	0	14 174
Al Qabil	137	1 844	0	0	1 981
Dama Wa At Taiyyin	1 436	5 464	0	0	6 900
Wadi Bani Khalid	688	2 619	0	0	3 308
Mahawat	0	2 240	0	0	2 240
Duqum	0	1 833	0	0	1 833
Hayma	0	1 883	0	0	1 883
Al Jazer	0	1 338	0	0	1 338
Salalah	18 705	165 352	0	2 183	186 240
Thumrayt	116	2 650	0	0	2 766
Taqah	113	2 056	0	0	2 169
Mirbat	100	2 064	0	0	2 164
Sadah	46	946	0	0	993
Rakhyut	32	667	0	0	700
Dalkut	20	416	0	0	437
Muqshin	8	158	0	0	166
Shalim Wa Juzur Al	63	1 289	0	0	1 352
Al Mazyunah	58	1 192	0	0	1 250
Al Buraimi	794	23 997	221	584	25 595
Mahadah	443	1 467	0	0	1 910
As Sinainah	73	243	0	0	316
Khasab	604	4 722	0	55	5 380
Bukha	110	723	0	0	833
Dibba	254	1 671	0	0	1 924
Mudha	118	779	0	0	897

be'ah (2013). Waste characterization and quantification - Final municipal waste survey, be'ah, Oman, 1-85 p.

Appendix 3 Collection clusters

Collection site name	Included wilayats	Governorate	Food waste	Park & garden waste	Other bio waste	Paper	Cardboard	Soft plastic	Other plastic	Ferrous metal	Non-ferrous metal	Glass	Wood waste	Textile	Bulky waste	Construction and demolition waste	Hazardous waste	WEEE	Other waste
Salalah	Salalah	Dhofar	48779	2480	165	3968	11079	23149	19346	1984	165	5291	4299	9756	0	0	0	2480	32740
	Thumrayt	Dhofar	782	40	3	64	178	371	310	32	3	85	69	156	0	0	0	40	525
	Taqah	Dhofar	607	31	2	49	138	288	241	25	2	66	53	121	0	0	0	31	407
	Mirbat	Dhofar	609	31	2	50	138	289	241	25	2	66	54	122	0	0	0	31	409
	Sadah	Dhofar	279	14	1	23	63	132	111	11	1	30	25	56	0	0	0	14	187
	Rakhyut	Dhofar	197	10	1	16	45	93	78	8	1	21	17	39	0	0	0	10	132
	Dalkut	Dhofar	123	6	0	10	28	58	49	5	0	13	11	25	0	0	0	6	82
Al Kamil	Sur	Ash Sharqiyah South	4173	316	171	342	1409	1053	1172	184	0	606	395	948	0	0	0	53	2357
	Jalan Bani Bu Ali	Ash Sharqiyah South	6159	466	253	505	2079	1554	1729	272	0	894	583	1399	0	0	0	78	3478
	Jalan Bani Bu Hassan	Ash Sharqiyah South	1591	120	65	131	537	402	447	70	0	231	151	361	0	0	0	20	899
	Al Kamil Wa Al Wafi	Ash Sharqiyah South	1107	84	45	91	374	279	311	49	0	161	105	251	0	0	0	14	625
	Ibra	Ash Sharqiyah North	1556	44	6	180	747	529	803	56	6	355	212	392	0	50	0	0	1288
	Bidiyah	Ash Sharqiyah North	2465	69	10	286	1183	838	1272	89	10	562	335	621	0	79	0	0	2041
	Al Qabil	Ash Sharqiyah North	461	13	2	53	221	157	238	17	2	105	63	116	0	15	0	0	382
	Wadi Bani Khalid	Ash Sharqiyah North	655	18	3	76	314	223	338	24	3	149	89	165	0	21	0	0	542
Muscat	Mutrah	Muscat	15387	1266	6261	5862	7127	9059	4796	1532	0	2398	999	4196	0	0	333	133	7194
	Bawshar	Muscat	18034	1483	7338	6870	8353	10617	5621	1796	0	2810	1171	4918	0	0	390	156	8431
	As Seeb	Muscat	23925	1968	9736	9114	11082	14086	7457	2382	0	3729	1554	6525	0	0	518	207	11186
	Al Amrat	Muscat	5162	425	2100	1966	2391	3039	1609	514	0	804	335	1408	0	0	112	45	2413
	Qurayyat	Muscat	2472	203	1006	942	1145	1456	771	246	0	385	161	674	0	0	54	21	1156
	Barka	Al Batinah South	11823	2202	41	1957	4281	3547	4199	734	41	1875	856	1875	41	41	82	82	7135
	Al Musanaah	Al Batinah South	3687	687	13	610	1335	1106	1310	229	13	585	267	585	13	13	25	25	2225
	Rustaq	Al Batinah South	5338	994	18	884	1933	1601	1896	331	18	847	387	847	18	18	37	37	3221
	Nakhal	Al Batinah South	744	139	3	123	269	223	264	46	3	118	54	118	3	3	5	5	449
	Al Awabi	Al Batinah South	1453	271	5	241	526	436	516	90	5	231	105	231	5	5	10	10	877
	Sumail	Ad Dakhliyah	3349	123	62	288	1048	904	894	185	21	360	226	668	31	0	10	31	2085
	Izki	Ad Dakhliyah	2240	82	41	192	701	605	598	124	14	240	151	447	21	0	7	21	1395
	Bid Bid	Ad Dakhliyah	2319	85	43	199	725	626	619	128	14	249	156	462	21	0	7	21	1444
	Dama Wa At Taiyyin	Ash Sharqiyah North	1366	38	5	158	656	464	705	49	5	311	186	344	0	44	0	0	1131
Sohar-Yanqul	Sohar	Al Batinah North	9969	1058	0	1790	4191	3906	4273	651	0	1790	1546	2401	326	0	41	244	8545
	As Suwayq	Al Batinah North	8912	946	0	1601	3747	3492	3820	582	0	1601	1382	2146	291	0	36	218	7639
	Saham	Al Batinah North	6987	741	0	1255	2937	2738	2994	456	0	1255	1084	1683	228	0	29	171	5989
	Shinas	Al Batinah North	3235	343	0	581	1360	1267	1386	211	0	581	502	779	106	0	13	79	2773
	Al Khabura	Al Batinah North	3197	339	0	574	1344	1253	1370	209	0	574	496	770	104	0	13	78	2740
	Liwa	Al Batinah North	1853	197	0	333	779	726	794	121	0	333	287	446	61	0	8	45	1588
	Wadi Al Maawal	Al Batinah South	644	120	2	107	233	193	229	40	2	102	47	102	2	2	4	4	389
	Ibri	Adh Dhahirah	4160	45	0	590	2178	1074	1724	227	0	620	166	1165	0	0	15	182	2995
	Yanqul	Adh Dhahirah	1108	12	0	157	580	286	459	60	0	165	44	310	0	0	4	48	798
	Dank	Adh Dhahirah	732	8	0	104	383	189	303	40	0	109	29	205	0	0	3	32	527
	Al Buraimi	Al Buraymi	6335	432	24	480	1656	3600	2160	168	96	1392	840	1368	504	0	0	0	4967
	Mahadah	Al Buraymi	387	26	1	29	101	220	132	10	6	85	51	84	31	0	0	0	304
	As Sinainah	Al Buraymi	64	4	0	5	17	36	22	2	1	14	9	14	5	0	0	0	50
Adam	Nizwa	Ad Dakhliyah	6038	222	111	519	1889	1630	1611	333	37	648	407	1204	56	0	19	56	3760
	Bahla	Ad Dakhliyah	2467	91	45	212	772	666	658	136	15	265	166	492	23	0	8	23	1536
	Al Hamra	Ad Dakhliyah	1552	57	29	133	486	419	414	86	10	167	105	309	14	0	5	14	966
	Adam	Ad Dakhliyah	1949	72	36	167	610	526	520	108	12	209	131	389	18	0	6	18	1213
	Manah	Ad Dakhliyah	1074	40	20	92	336	290	287	59	7	115	72	214	10	0	3	10	669
	Al Mudaybi	Ash Sharqiyah North	1319	37	5	153	633	449	681	47	5	301	179	332	0	42	0	0	1092

be'ah (2013). Waste characterization and quantification - Final municipal waste survey, be'ah, Oman, 1-85 p.

Appendix 4 Final collection clusters

Collection cluster name	Park & Garden Waste	Municipal Waste	Slaughter	Industrial waste	Total	% of tot
Salalah	19 132	174 151	0	2 183	195 469	18,22 %
Al Kamil	11 866	64 651	40	1 055	77 612	7,23 %
Muscat	50 150	390 484	603	58 648	499 888	46,60 %
Sohar-Yanqul	26 366	186 923	663	16 212	230 165	21,46 %
Adam	2 756	45 397	74	774	49 001	4,57 %
Total	110 270	861 606	1 380	78 872	1 052 135	98,08 %

Collection cluster name	Park & Garden Waste	Municipal Waste	Slaughter	Industrial waste	Total	% of tot
Musandam	968	7 116	0	55	8 139	0,76 %

be'ah (2013). Waste characterization and quantification - Final municipal waste survey, be'ah, Oman, 1-85 p.

Appendix 5 Decision-making simulation identified values

1st iteration

		Financial						Ecological					Social			Utility		
		Net present value	Payback time	IRR (project)	Demand for side products	Consumption of scarce resources	Initial investment	Waste disposal	Environmental safety	Low emissions	Compact	Waste hierarchy	PR-value for be'ah and Oman (National and International)	BAT	Consumer preference	Availability	Need for service	Complexity
	Weight	3	3	1	5	5	4	5	4	3	1	2	4	4	2	3	3	3
Technology alternative 1	Salalah	0,52	0,00	1,19	2	1	1,28	3	4	4	3	3	4	4	3	4	4	4
Technology alternative 2	Salalah	0,86	2,50	3,51	4	1	0,26	4	5	4	4	4	3	3	2	4	3	3
Technology alternative 3	Salalah	1,62	3,33	2,68	4	1	2,18	3	4	4	2	3	5	4	5	3	5	4
Technology alternative 4	Salalah	1,27	5,00	2,14	4	1	2,74	3	4	4	2	3	5	4	5	3	5	4
Technology alternative 5	Salalah	0,27	0,00	0,00	2	1	1,28	2	3	4	2	3	3	5	3	3	5	5
Technology alternative 6	Salalah	0,35	0,00	0,00	2	1	1,61	3	3	3	5	2	2	3	2	3	5	2
Technology alternative 7	Salalah	0,23	0,00	0,00	1	2	0,15	5	1	5	2	1	1	1	1	5	1	1
Technology alternative 5	Al Kamil	0,52	0,00	0,58	2	1	0,37	2	3	4	2	3	3	5	3	3	5	5
Technology alternative 7	Al Kamil	0,49	0,00	0,00	1	2	0,00	5	1	5	2	1	1	1	1	5	1	1
Technology alternative 1	Muscat	0,45	0,00	1,22	2	1	3,31	3	4	4	3	3	4	4	3	4	4	4
Technology alternative 2	Muscat	1,33	2,08	3,79	3	1	0,71	4	5	4	4	4	3	3	2	4	3	3
Technology alternative 3	Muscat	5,00	1,67	4,47	5	1	3,53	3	4	4	2	3	5	4	5	3	5	4
Technology alternative 4	Muscat	3,47	2,92	2,94	5	1	5,00	3	4	4	2	3	5	4	5	3	5	4
Technology alternative 5	Muscat	0,15	0,00	0,71	2	1	3,53	2	3	4	2	3	3	5	3	3	5	5
Technology alternative 6	Muscat	0,31	0,00	0,00	2	1	3,31	3	3	3	5	2	2	3	2	3	5	2
Technology alternative 7	Muscat	0,00	0,00	0,48	1	2	0,15	5	1	5	2	1	1	1	1	5	1	1
Technology alternative 1	Sohar	0,54	0,00	1,26	3	1	1,28	3	4	4	3	3	4	4	3	4	4	4
Technology alternative 2	Sohar	3,14	1,25	5,00	1	1	1,61	4	5	4	4	4	3	3	2	4	3	3
Technology alternative 3	Sohar	2,01	2,92	3,09	5	1	2,18	3	4	4	2	3	5	4	5	3	5	4
Technology alternative 4	Sohar	1,71	3,75	2,54	4	1	2,74	3	4	4	2	3	5	4	5	3	5	4
Technology alternative 5	Sohar	0,33	0,00	0,52	2	1	1,05	2	3	4	2	3	3	5	3	3	5	5
Technology alternative 6	Sohar	0,35	0,00	0,00	2	1	1,61	3	3	3	5	2	2	3	2	3	5	2
Technology alternative 7	Sohar	0,43	0,00	0,71	1	2	0,15	5	1	5	2	1	1	1	1	5	1	1
Technology alternative 5	Adam	0,49	0,00	0,00	2	1	0,32	2	3	4	2	3	3	5	3	3	5	5
Technology alternative 7	Adam	0,49	0,00	0,00	1	2	0,00	5	1	5	2	1	1	1	1	5	1	1

2nd iteration

		Financial						Ecological					Social			Utility		
		Net present value	Payback time	IRR (project)	Demand for side products	Consumption of scarce resources	Initial investment	Waste disposal	Environmental safety	Low emissions	Compact	Waste hierarchy	PR-value for be'ah and Oman (National and International)	BAT	Consumer preference	Availability	Need for service	Complexity
	Weight	3	3	1	5	5	3	5	4	4	3	2	5	4	2	3	3	2
Technology alternative 1	Salalah	0,52	0,00	1,19	2	1	1,28	3	4	4	3	3	4	4	3	4	4	4
Technology alternative 2	Salalah	0,86	2,50	3,51	4	1	0,26	4	5	4	4	4	3	3	2	4	3	3
Technology alternative 3	Salalah	1,62	3,33	2,68	4	1	2,18	3	4	4	2	3	5	4	5	3	5	4
Technology alternative 4	Salalah	1,27	5,00	2,14	4	1	2,74	3	4	4	2	3	5	4	5	3	5	4
Technology alternative 5	Salalah	0,27	0,00	0,00	2	1	1,28	2	3	4	2	3	3	5	3	3	5	5
Technology alternative 6	Salalah	0,35	0,00	0,00	2	1	1,61	3	3	3	5	2	2	3	2	3	5	2
Technology alternative 7	Salalah	0,23	0,00	0,00	1	2	0,15	5	1	5	2	1	1	1	1	5	1	1
Technology alternative 5	Al Kamil	0,52	0,00	0,58	2	1	0,37	2	3	4	2	3	3	5	3	3	5	5
Technology alternative 7	Al Kamil	0,49	0,00	0,00	1	2	0,00	5	1	5	2	1	1	1	1	5	1	1
Technology alternative 1	Muscat	0,45	0,00	1,22	2	1	3,31	3	4	4	3	3	4	4	3	4	4	4
Technology alternative 2	Muscat	1,33	2,08	3,79	3	1	0,71	4	5	4	4	4	3	3	2	4	3	3
Technology alternative 3	Muscat	5,00	1,67	4,47	5	1	3,53	3	4	4	2	3	5	4	5	3	5	4
Technology alternative 4	Muscat	3,47	2,92	2,94	5	1	5,00	3	4	4	2	3	5	4	5	3	5	4
Technology alternative 5	Muscat	0,15	0,00	0,71	2	1	3,53	2	3	4	2	3	3	5	3	3	5	5
Technology alternative 6	Muscat	0,31	0,00	0,00	2	1	3,31	3	3	3	5	2	2	3	2	3	5	2
Technology alternative 7	Muscat	0,00	0,00	0,48	1	2	0,15	5	1	5	2	1	1	1	1	5	1	1
Technology alternative 1	Sohar	0,54	0,00	1,26	3	1	1,28	3	4	4	3	3	4	4	3	4	4	4
Technology alternative 2	Sohar	3,14	1,25	5,00	1	1	1,61	4	5	4	4	4	3	3	2	4	3	3
Technology alternative 3	Sohar	2,01	2,92	3,09	5	1	2,18	3	4	4	2	3	5	4	5	3	5	4
Technology alternative 4	Sohar	1,71	3,75	2,54	4	1	2,74	3	4	4	2	3	5	4	5	3	5	4
Technology alternative 5	Sohar	0,33	0,00	0,52	2	1	1,05	2	3	4	2	3	3	5	3	3	5	5
Technology alternative 6	Sohar	0,35	0,00	0,00	2	1	1,61	3	3	3	5	2	2	3	2	3	5	2
Technology alternative 7	Sohar	0,43	0,00	0,71	1	2	0,15	5	1	5	2	1	1	1	1	5	1	1
Technology alternative 5	Adam	0,49	0,00	0,00	2	1	0,32	2	3	4	2	3	3	5	3	3	5	5
Technology alternative 7	Adam	0,49	0,00	0,00	1	2	0,00	5	1	5	2	1	1	1	1	5	1	1

3rd iteration

		Financial					Ecological					Social			Utility			
		Net present value	Payback time	IRR (project)	Initial investment	Demand for side products	Waste disposal	Environmental safety	Low emissions	Consumption of scarce resources	Waste hierarchy	PR-value for be'ah and Oman (National and International)	BAT	Consumer preference	Compact	Availability	Need for service	Complexity
	Weight	4	4	4	3	4	5	4	4	5	1	5	4	2	3	3	3	2
Technology alternative 1	Salalah	0,52	0,00	1,19	1,28	2	3	4	4	1	3	4	4	3	3	4	4	4
Technology alternative 2	Salalah	0,86	2,50	3,51	0,26	4	4	5	4	1	4	3	3	2	4	4	2	3
Technology alternative 3	Salalah	1,62	3,33	2,68	2,18	4	3	4	4	1	3	5	4	5	2	3	5	4
Technology alternative 4	Salalah	1,27	5,00	2,14	2,74	4	3	4	4	1	3	5	4	5	2	3	5	4
Technology alternative 5	Salalah	0,27	0,00	0,00	1,28	2	2	2	4	1	3	4	5	3	2	3	5	5
Technology alternative 6	Salalah	0,35	0,00	0,00	1,61	2	3	3	4	1	2	2	3	2	5	4	5	2
Technology alternative 7	Salalah	0,23	0,00	0,00	0,15	1	5	1	3	2	1	1	1	1	2	5	1	1
Technology alternative 5	Al Kamil	0,52	0,00	0,58	0,37	2	2	3	4	1	3	3	5	3	2	3	5	5
Technology alternative 7	Al Kamil	0,49	0,00	0,00	0,00	1	5	1	5	2	1	1	1	1	2	5	1	1
Technology alternative 1	Muscat	0,45	0,00	1,22	3,31	2	3	4	4	1	3	4	4	3	3	4	4	4
Technology alternative 2	Muscat	1,33	2,08	3,79	0,71	3	4	5	4	1	4	3	3	2	4	4	3	3
Technology alternative 3	Muscat	5,00	1,67	4,47	3,53	5	3	4	4	1	3	5	4	5	2	3	5	4
Technology alternative 4	Muscat	3,47	2,92	2,94	5,00	5	3	4	4	1	3	5	4	5	2	3	5	4
Technology alternative 5	Muscat	0,15	0,00	0,71	3,53	2	2	3	4	1	3	3	5	3	2	3	5	5
Technology alternative 6	Muscat	0,31	0,00	0,00	3,31	2	3	3	3	1	2	2	3	2	5	3	5	2
Technology alternative 7	Muscat	0,00	0,00	0,48	0,15	1	5	1	5	2	1	1	1	1	2	5	1	1
Technology alternative 1	Sohar	0,54	0,00	1,26	1,28	3	3	4	4	1	3	4	4	3	3	4	4	4
Technology alternative 2	Sohar	3,14	1,25	5,00	1,61	1	4	5	4	1	4	3	3	2	4	4	3	3
Technology alternative 3	Sohar	2,01	2,92	3,09	2,18	5	3	4	4	1	3	5	4	5	2	3	5	4
Technology alternative 4	Sohar	1,71	3,75	2,54	2,74	4	3	4	4	1	3	5	4	5	2	3	5	4
Technology alternative 5	Sohar	0,33	0,00	0,52	1,05	2	2	3	4	1	3	3	5	3	2	3	5	5
Technology alternative 6	Sohar	0,35	0,00	0,00	1,61	2	3	3	3	1	2	2	3	2	5	3	5	2
Technology alternative 7	Sohar	0,43	0,00	0,71	0,15	1	5	1	5	2	1	1	1	1	2	5	1	1
Technology alternative 5	Adam	0,49	0,00	0,00	0,32	2	2	3	4	1	3	3	5	3	2	3	5	5
Technology alternative 7	Adam	0,49	0,00	0,00	0,00	1	5	1	5	2	1	1	1	1	2	5	1	1

Appendix 6 Business Model Canvas

Key Partners

- Consultancy company 1
- Consultancy company 2
- Consultancy company 3
- be'ah
- Local authorities
- Strategic technology suppliers
- Equipment and machine suppliers
- Subcontractors and workshops
- Logistics companies

Key Activities

- Project management
- Problem solving
- Designing and planning
- Creating layouts
- Subcontracting
- Assembly
- Manufacturing

Key Resources

- Human resources
- Raw materials
- Capital resources
- Manufacturing and assembly machinery and equipment
- Assembly facilities

Value Propositions

- SRF replaces fossil fuels
- SRF functions as auxiliary fuel
- Waste disposal
- Economically feasible
- Lower emissions
- Environmentally sustainable
- Increased PR image
- Increased recycling efficiency

Customer Relationships

- Created customer by local company and consulting companies 1 and 2.
- Dedicated contacts
- "Over quality" service
- Focus in beginning in getting a stellar reference

Channels

- Direct sales contacts
- No online or physical store
- In person negotiations and meetings
- Visits to site to communicate periodically with the customer
- Possibility to later invest in local warehousing of spare and wear parts
- Outsourced service operations
- Possibility to outsource some spare part manufacturing for local companies

Customer Segments

- Niche market
- Only business to business
- Relatively few amount of businesses are interested in investing in waste processing plant
- Business model focused on a certain targeted geographical area

Cost Structure

- Operating more on a value driven focus than on a cost driven focus
- Bill of materials
- Labor and fixed cost salaries
- Outsourced components, machinery, technology, and other
- Logistics costs
- Some manufacturing could be outsourced to the local area

Revenue Streams

- Revenue mostly from project delivery
- Possibility to utilize the letter of credit method, but might not be necessary
- The basic service and spare and wear parts business should be in focus to ensure the customer profitability and the reference value of the important plants
- Aftersales could additionally include, for example, services for installing, adjusting and optimization, training and educating the operating staff and producing extra and more detailed documentation